COMPREHENSIVE ASSESSMENT AND MONITORING PROGRAM

Assessment of Anadromous Fish Production in the Central Valley of California between 1992 and 2008

Report prepared by the
United States Department of the Interior
U.S. Fish and Wildlife Service
and
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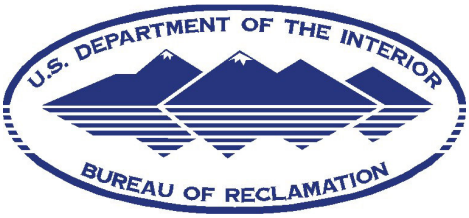

2009

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2009

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ACRONYMS AND ABBREVIATIONS

AFRP	Anadromous Fish Restoration Program
CAMP	Comprehensive Assessment and Monitoring Program
CDFG	California Department of Fish and Game
CVPIA	Central Valley Project Improvement Act
MWT	midwater trawl
PFMC	Pacific Fishery Management Council
USFWS	U.S. Fish and Wildlife Service
YOY	young-of-the-year

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EXECUTIVE SUMMARY

This Comprehensive Assessment and Monitoring Program (CAMP) annual report compiles and synthesizes anadromous fish production data from the Central Valley of California between 1992 and 2008. These data are then used to assess overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to Section 3406(b) of the Central Valley Project Improvement Act (CVPIA) in meeting fish production targets developed by the Anadromous Fish Restoration Program (AFRP). To accomplish these tasks, this report quantifies the *natural* (as compared to hatchery) production of eight anadromous fish taxa in one broader area and 22 Central Valley watersheds where AFRP fish production targets exist. The eight fish taxa include fall-, late-fall-, winter-, and spring-run Chinook salmon; striped bass; American shad; white sturgeon; and green sturgeon. The broader area includes San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin River Delta. The 22 watersheds are the American River, Antelope Creek, Battle Creek, Bear River, Big Chico Creek, Butte Creek, Calaveras River, Clear Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Feather River, Merced River, Mill Creek, seven "miscellaneous creeks" above the Red Bluff Diversion Dam, Mokelumne River, Paynes Creek, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River. The CAMP can not assess progress toward the AFRP's steelhead production target because comparable monitoring data before and after 1994 can not be collected for this taxon.

The AFRP production targets for Chinook salmon consist of three tiers that include: (1) watershed-specific production targets for different locations and runs of Chinook salmon, (2) a run-specific production target for each of the four runs of Chinook salmon in the Central Valley, and (3) a Central Valley-wide production target for the combined total of all four runs of Chinook salmon. The production targets for white and green sturgeon, American shad, and striped bass only consist of one tier in the Central Valley.

Progress toward the AFRP production targets for the eight taxa was assessed by: (1) quantifying the number of years AFRP production targets were met after 1991, (2) determining if average natural production of adult Chinook salmon from each watershed during the 1967-1991 baseline period was greater or less than production during the 1992-2008 post-baseline period, and (3) determining if there is a statistically significant ($\alpha = 0.05$) difference in the average natural production of adult Chinook salmon from each watershed between these two time periods. Monitoring data quantifying the natural production of adult Chinook salmon from the Central Valley during the 17-year period between 1992 and 2008 are summarized in Table 1.

Table 1. Overall assessment of changes in natural production of adult Chinook salmon from the Central Valley, 1967-2008. * Indicates a fish hatchery is present in the watershed; presence of hatchery fish can confound estimates of natural production. ** P values <0.05 reflect a statistically significant change. ??? = insufficient data to assess change in average production or a P value.

Watershed	Chinook salmon run	Number of years the AFRP production target was exceeded / number of years monitoring occurred since 1991	Change in average production between the 1967-1991 and 1992-2008 time periods	P values associated with changes in the average production between the 1967-1991 and 1992-2008 time periods
American River*	fall-run	6/17	+ 51%	0.056
Antelope Creek	fall-run	0/0	???	???
Battle Creek*	fall-run	13/17	+ 295%	0.000**
Battle Creek*	late-fall-run	9/17	+ 147%	0.004**
Bear River	fall-run	0/0	???	???
Big Chico Creek	fall-run	0/0	???	???
Butte Creek	fall-run	8/12	+ 269%	0.008**
Butte Creek	spring-run	14/17	+ 976%	0.000**
Calaveras River	winter-run	0/0	???	???
Clear Creek	fall-run	11/17	+ 225%	0.000**
Cosumnes River	fall-run	0/3	- 77%	???
Cottonwood Creek	fall-run	0/3	- 36%	???
Cow Creek	fall-run	1/3	+ 16%	???
Deer Creek	fall-run	2/9	+ 31%	0.600
Deer Creek	spring-run	0/17	- 29%	0.974
Feather River*	fall-run	3/17	+ 18%	0.214
Merced River*	fall-run	1/17	- 16%	0.599
Mill Creek	fall-run	1/12	+ 4%	0.283
Mill Creek	spring-run	0/17	- 40%	0.262
“miscellaneous creeks”	fall-run	0/2	- 79%	???
Mokelumne River*	fall-run	8/17	+ 83%	0.010**
Paynes Creek	fall-run	0/0	????	???
Sacramento River	fall-run	0/17	- 28%	0.019**
Sacramento River	late-fall-run	1/16	- 40%	0.017**
Sacramento River*	winter-run	0/17	- 86%	0.007**
Sacramento River	spring-run	0/16	- 97%	0.000**
Stanislaus River	fall-run	0/17	- 44%	0.525
Tuolumne River	fall-run	0/17	- 58%	0.044**
Yuba River	fall-run	1/17	+ 6%	0.497

The presence of fish hatcheries in several watersheds may confound the ability to accurately assess salmon production because the proportion of natural- vs. hatchery-reared salmon that is needed to calculate natural production is not currently known.

During the 17-year period between 1992 and 2008, the available monitoring data in Table 1 indicate:

- Monitoring data that can be used to estimate salmon production have not been collected during the 1992-2008 post-baseline period in five of the 22 watersheds that have an AFRP fish production target. These watersheds are relatively small and consist of Antelope Creek, Bear River, Big Chico Creek, Calaveras River, and Paynes Creek. Six of the seven "miscellaneous creeks" also have not been surveyed during the post-baseline period.

- The watershed-specific AFRP fall-run Chinook salmon production targets were met six or more times in five of the 21 watersheds with a fall-run target. These watersheds are: American River, Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River. The remaining 16 watersheds with a fall-run Chinook salmon target have: (a) met their production targets less than three times during the 17-year post-baseline period, or (b) were not surveyed each year since 1991.

- The watershed-specific AFRP late-fall-run Chinook salmon production target for Battle Creek was met nine times in the post-baseline period, and the Sacramento River mainstem has only met its AFRP late-fall-run Chinook salmon target once.

- The watershed-specific AFRP winter-run Chinook salmon production target for the Sacramento River mainstem has never been met during the post-baseline period, and monitoring data have not been collected from the Calaveras River to assess progress toward its AFRP winter-run Chinook salmon target.

- The watershed-specific AFRP spring-run Chinook salmon production target was met 14 times on Butte Creek in the post-baseline period. The other three watersheds with a spring-run Chinook salmon target (Deer Creek, Mill Creek, and the Sacramento River mainstem) have never met their AFRP targets in the post-baseline period.

- Run-specific AFRP production targets for fall-, winter-, and spring-run Chinook salmon were never met in the post-baseline period, and the run-specific AFRP production target for late-fall-run Chinook salmon was met once.

- The Central Valley-wide AFRP production target for the combined total of all four runs of Chinook salmon was never met in the post-baseline period.

Other data presented in this report demonstrate that:

- Six combinations of watersheds and runs have significantly greater numbers of Chinook salmon in the post-baseline period than during the 1967-1991 baseline period. In contrast, five combinations of watersheds and runs have significantly fewer numbers of Chinook salmon. In nine combinations of watersheds and runs, there were no significant changes over time, and there were nine combinations where insufficient monitoring data were collected to determine if there was a significant change.

- Chinook salmon production estimates in 2008 are unusual in comparison to past years because they do not include an ocean harvest component. That component normally accounts for a substantial fraction of Chinook salmon production. The elimination of ocean harvest of Chinook salmon does not appear to have led to substantially larger numbers of adult salmon that returned to the Central Valley to spawn.

- For the watersheds where monitoring data were available, production of different runs of Chinook salmon from the aforementioned 22 watersheds declined in 20 of the 22 combinations of watersheds and runs in 2008 relative to 2007.

- Progress in achieving the Chinook salmon production targets called for in the CVPIA has become increasing difficult since 2000. In that year, 47% of the watersheds that were monitored exceeded their AFRP production target. By 2008, only 9% of the monitored watersheds exceeded their AFRP target. The recent decline in Chinook salmon production has become so substantial that only 14% of the watersheds monitored in 2008 exceeded the production levels observed during the 1967-1991 baseline period.

With respect to non-salmonid species:

- Monitoring data for white sturgeon in San Pablo and Suisun bays are available for seven years between 1992 and 2005. The AFRP production target for 15-year-old white sturgeon was met once in those seven years. White sturgeon data for the post-2005 period are not currently available.

- Monitoring data for green sturgeon in San Pablo and Suisun bays are available for six years between 1992 and 2005. The AFRP production target for green sturgeon ≥ 40 inches in length was met twice in those six years. Green sturgeon data for the post-2005 period are not currently available.

- The midwater trawl index for juvenile American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays suggests the AFRP production target for this species was met in three of 17 years between 1992 and 2008. The 2008 midwater trawl index for this species is the lowest value recorded during the 1992-2008 time period.

- Monitoring of adult striped bass in the Sacramento-San Joaquin River Delta and the lower portions of the Sacramento and San Joaquin rivers occurred in 11 of the years between 1992 and 2007. In the eight years during this period when bass abundance

estimates are considered to be final and not subject to revision, the AFRP production target for this species was never met. In the three years (2004, 2005, and 2007) when the abundance estimates are considered to be provisional, it is unlikely that future revisions will result in the attainment of the AFRP production target because any revisions are likely to be minor and the provisional estimates are markedly below the AFRP production target.

SECTION 1: INTRODUCTION

1.1 OVERVIEW OF THE CVPIA, AFRP, AND CAMP

The CVPIA was authorized in October 1992 (Public Law 102-575, Title 34), and amends the authority of the Central Valley Project to include fish and wildlife protection, restoration, and mitigation activities as having equal priority with other Central Valley Project functions. Section 3406(b)(1) of the CVPIA directs the Secretary of the Interior to "…implement a program which makes all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991." The CVPIA defines natural production as "fish produced to adulthood without direct human intervention in the spawning, rearing, or migration processes."

Pursuant to Section 3406(b)(1) of the CVPIA, the AFRP was established to restore anadromous fish populations through a variety of management strategies. The CAMP was established pursuant to CVPIA section 3406(b)(16) to "…monitor fish and wildlife resources in the Central Valley to assess the biological results and effectiveness of actions implemented pursuant to subsection [3406(b)]".

In 1994, the California Department of Fish and Game (CDFG) issued a report that quantified abundance of fish taxa in the Central Valley between 1967 and 1991 (Mills and Fisher 1994). The AFRP used the CDFG fish abundance estimates to develop production targets for nine anadromous fish taxa in one broader area and 22 watersheds in the Central Valley. These AFRP production targets are twice the average levels during the 1967-1991 baseline period and are quantified in the *Final Restoration Plan for the Anadromous Fish Restoration Program* (USFWS 2001). The nine fish taxa include fall-, late-fall-, winter-, and spring-run Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), striped bass (*Morone saxatilis*), American shad (*Alosa sapidissima*), white sturgeon (*Acipenser transmontanus*), and green sturgeon (*Acipenser medirostris*). The broader area includes San Pablo Bay, Suisun Bay, and the Sacramento-San Joaquin River Delta (Bay-Delta), and the 22 watersheds are the American River, Antelope Creek, Battle Creek, Bear River, Big Chico Creek, Butte Creek, Calaveras River, Clear Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Feather River, Merced River, Mill Creek, seven "miscellaneous creeks" above the Red Bluff Diversion Dam, Mokelumne River, Paynes Creek, Sacramento River mainstem, Stanislaus River, Tuolumne River, and Yuba River.

To address its mandate, the CAMP attempts to produce annual reports that compile and synthesize anadromous fish production data from the Central Valley. These data are used to assess overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to CVPIA Section 3406(b) in meeting the AFRP fish production targets; the habitat restoration actions include water management modifications, structural modifications, habitat restoration, and fish screens. This is the seventh CAMP annual report prepared since 1992. Each CAMP annual report is available on the CAMP website at:
http://www.fws.gov/sacramento/CAMP/camp_documents_and_projects.htm

CAMP annual reports do not estimate production of fish that originate at fish hatcheries. For purposes of this report: (1) the word "taxa" refers to different species of anadromous fish or different runs of Chinook salmon, (2) references to the "baseline period" reflect the years between 1967 and 1991, and (3) references to the "post-baseline period" or "post-baseline" include the years 1992, 1993, 1994, etc. to the present day.

1.2 PRODUCTION TARGETS FOR ANADROMOUS FISH

The AFRP has developed baseline production estimates and fish production targets for each of the abovementioned taxa (Table 2). With regard to natural production of Chinook salmon, the AFRP developed three tiers of production targets (Figure 1). These include: (1) watershed-specific production targets for different runs of Chinook salmon, (2) run-specific production targets for each run of Chinook salmon, and (3) a Central Valley-wide production target for the combined total of all four runs of Chinook salmon. Figure 1 provides an illustration that demonstrates how the three tiers of production targets are interrelated. In contrast to the Chinook salmon production targets, the targets for striped bass, American shad, white sturgeon, and green sturgeon are not tiered and there is only one production target for each of these species.

The Chinook salmon baseline production estimates provided in the 2007 and 2008 CAMP annual reports (USFWS 2007, 2008) reported rounded values provided on page 3-Xa-2 of Volume 3 of the AFRP's *Working Paper on Restoration Needs* (USFWS 1995). In this and subsequent CAMP annual reports, the CAMP will adopt Chinook salmon baseline production estimates that are unrounded (e.g., 80,874 vs. 81,000) and reflect the watersheds and runs where an AFRP production target was developed. This change was made to ensure that the AFRP and CAMP rely on and reference the same set of baseline numbers.

CAMP annual reports can not address progress toward the AFRP's steelhead production target for reasons explained in the 2007 CAMP annual report (USFWS 2007). In short, it is not possible to assess progress toward the AFRP production target for adult steelhead because operational changes at the Red Bluff Diversion Dam after 1994 preclude the ability to collect comparable post-baseline data for this taxon.

Table 2. Anadromous Fish Restoration Program fish production targets. With the exception of American shad, all production targets pertain to adult fish.

Taxa	**Watershed/area**	**1967-1991 baseline production estimate**	**AFRP production target**
CHINOOK SALMON			
Fall-run	American River*	80,874	160,000
	Antelope Creek	361	720
	Battle Creek*	5,013	10,000
	Bear River	639	450
	Big Chico Creek	402	800
	Butte Creek	765	1,500
	Clear Creek	3,576	7,100
	Cosumnes River	1,660	3,300
	Cottonwood Creek	2,964	5,900
	Cow Creek	2,330	4,600
	Deer Creek	766	1,500
	Feather River*	86,028	170,000
	Merced River*	9,005	18,000
	Mill Creek	2,118	4,200
	"miscellaneous creeks"	549	1,100
	Mokelumne River*	4,680	9,300
	Paynes Creek	170	330
	Sacramento River mainstem	115,369	230,000
	Stanislaus River	10,868	22,000
	Tuolumne River	18,949	38,000
	Yuba River	33,267	66,000
Late-fall-run	Battle Creek*	273	550
	Sacramento River mainstem	33,941	68,000
Winter-run	Calaveras River[1]	770	2,200
	Sacramento River mainstem*	54,316	110,000
Spring-run	Butte Creek	1,018	2,000
	Deer Creek	3,276	6,500
	Mill Creek	2,202	4,400
	Sacramento River mainstem	29,412	59,000

Table 2 (cont.). Anadromous Fish Restoration Program fish production targets.

Taxa	Watershed/area	1967-1991 baseline production estimate	AFRP production target
CHINOOK SALMON			
Fall-run		374,064	750,000
Late-fall-run		34,192	68,000
Winter-run		54,439	110,000
Spring-run run		34,374	68,000
Central Valley-wide (all 4 salmon runs combined)		497,069	990,000
STEELHEAD	Sacramento River upstream of Red Bluff Diversion Dam	6,546	13,000
STRIPED BASS	Sacramento-San Joaquin River Delta, and the lower portions of the Sacramento and San Joaquin rivers	1,252,259	2,500,00
AMERICAN SHAD[2]	Sacramento-San Joaquin River Delta, San Pablo Bay, and Suisun Bay	2,129	4,300
WHITE STURGEON[3]	San Pablo and Suisun bays	5,571	11,000
GREEN STURGEON[3]	San Pablo and Suisun bays	983	2,000

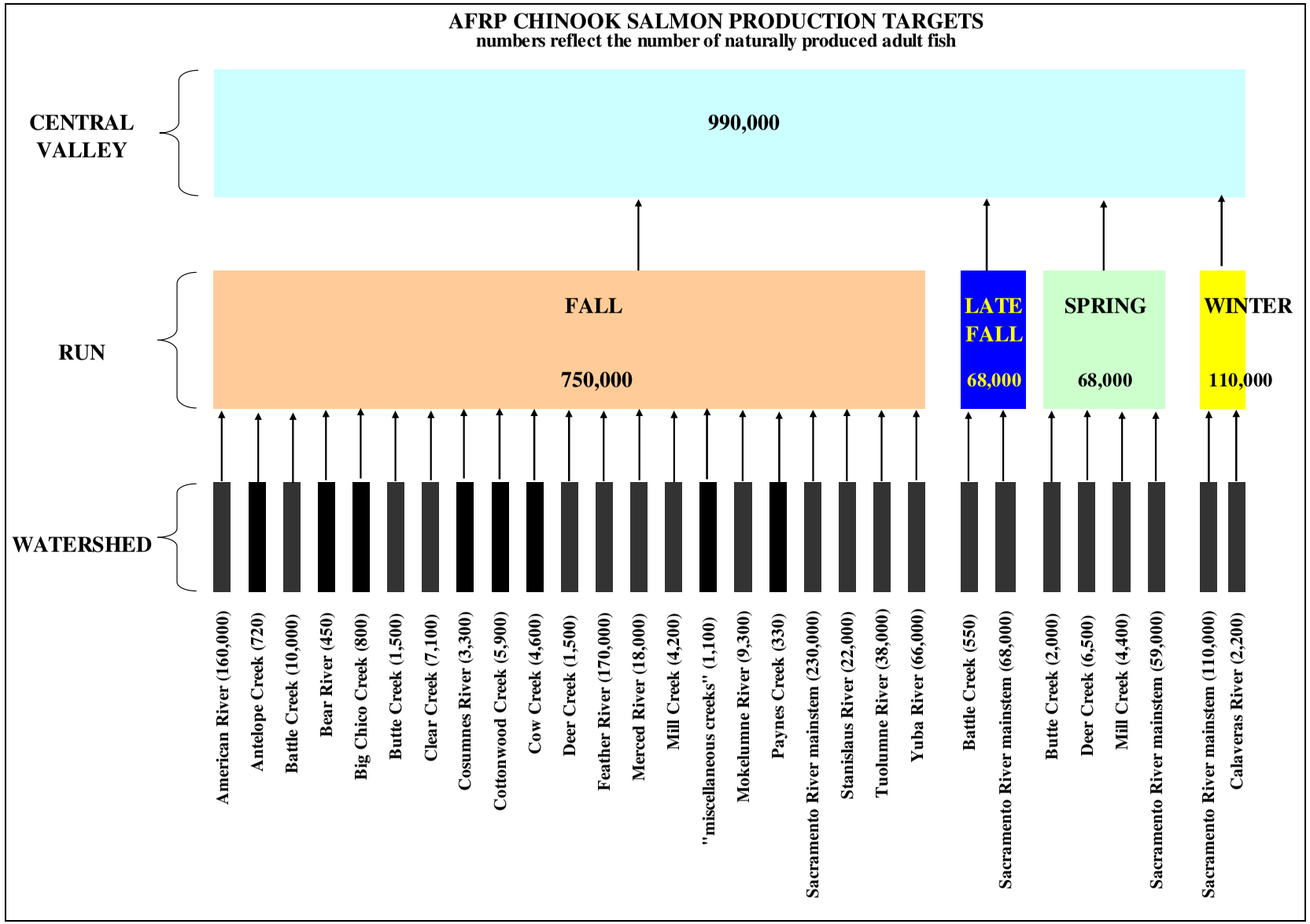
* = Hatchery in the tributary.

1 = Yoshiyama et al. (2001) suggest winter-run Chinook salmon may not have existed in the Calaveras River. The putative winter-run fish may actually have been a late-fall-run attracted to the river when flows were released in late winter and spring by New Hogan Dam.

2 = the baseline production estimate and production target for American shad is based on the midwater trawl index for young-of-the-year fish.

3 = the baseline production estimates and production targets for white and green sturgeon refer to 15-year old adult fish and fish ≥ 40 inches in total length, respectively.

Figure 1. Relationship between the three tiers of AFRP Chinook salmon production targets.



1.3 DATA CAVEATS

The fish production estimates presented in CAMP annual reports represent the best available information at the time of report production. These estimates are based on digital files maintained by the AFRP and the CDFG. It is important to note that fish production estimates for a given year, location, and taxa frequently differ in different iterations of the CAMP annual reports. These differences arise as the CDFG and AFRP staff update the digital files used to track fish abundance/production.

Several factors affect the accuracy and/or precision of data and analyses provided in the CAMP annual reports. Some of these factors include, but are not limited to:

1. The CAMP-recommended process for calculating Chinook salmon production requires an accurate understanding of the relative abundance of natural- vs. hatchery-origin salmon in each watershed. Because the amount of data pertaining to this ratio prior to 2009 is limited, the process of calculating natural production has thus far relied upon best professional judgments of the ratio of natural- vs. hatchery-origin fish in each watershed. Potential problems associated with not having definitive data on the ratio are more pronounced for fall-run Chinook salmon because large numbers of this run are produced and not marked. In contrast, the problem is minimal for spring-, late-fall-, and winter-run Chinook salmon because all the hatchery-produced fish of these runs are marked and recognizable in the field. The hatchery proportion issue for fall-run Chinook salmon should be come less pronounced in future years because large numbers of these salmon have been marked at Central Valley fish hatcheries since the spring of 2007, and it will gradually become possible to replace the best professional judgments with empirically-based hatchery proportions based on the recovery of marked salmon.

2. The CAMP has not attempted to determine how changes in sampling methods, frequency, or intensity at a given location have changed over time. These changes have the potential to affect fish abundance estimates.

3. Agency staff use different criteria, e.g. run timing, to assign Chinook salmon to particular runs. The dates when the four runs of Chinook salmon return to a natal stream may overlap and there are not distinct, non-overlapping periods when each run of salmon return to spawn. In general, fishery biologists believe problems with using run timing to identify different runs of Chinook salmon are relatively small, because other features (e.g., phenotypic differences or spawning condition) also provide clues as to the taxonomic identity of a particular salmon. Similarly, the ability to accurately identify spring-run Chinook salmon is enhanced because they tend to migrate farther up-stream than fall-run Chinook salmon, and hold over in deep pools during summer when the adult life phase of other salmon runs tend to be absent. However, there is the potential that fishery biologists could mistakenly assign individual fish to the wrong run of Chinook salmon, and thereby bias the number of salmon that are attributable to a particular run.

4. The CAMP-recommended process for calculating Chinook salmon production in each watershed should include an estimate of the number of fish *harvested downstream of the watershed*; i.e., downstream angler harvest. Because harvest of Chinook salmon between the Pacific Ocean and the Central Valley watersheds has not been consistently monitored (i.e., harvest is frequently not monitored in the Sacramento-San Joaquin River Delta or San Francisco Bay), this harvest may not be accurately accounted for in production estimates for individual watersheds, runs, or the Central Valley as a whole.

5. The CAMP-recommended process for calculating Chinook salmon production in each watershed should include an estimate of the number of fish *harvested in each watershed*; i.e., in-river angler harvest. Because the amount of in-river angler harvest has not been monitored on a consistent basis, the production estimate for a watershed only includes a best professional judgment of the amount of in-river angler harvest and does not include an actual count of the number of angler-harvested salmon.

6. The production estimates presented in this report may be subject to future revision as agency staff refine and analyze raw data.

1.4 ACKNOWLEDGEMENTS

This report would not have been possible without the substantial support of several individuals:

1. Rick Burmester in the U.S. Fish and Wildlife Service (USFWS) Stockton Fish and Wildlife Office invests a substantial effort to maintain the Chinookprod spreadsheet that tabulates values related to the production of Chinook salmon.

2. Jason Azat and other CDFG staff have invested substantial time in developing and maintaining the GrandTab spreadsheet that provides escapement estimates of Chinook salmon.

3. Marty Gingras (CDFG) and Mike Donnellon (formerly of the CDFG) provided spreadsheets that summarize data relative to the abundance of adult green and white sturgeon.

4. Dave Contreras of the CDFG provided spreadsheets that contain abundance data for juvenile American shad.

5. Jason DuBois of the CDFG provided abundance data for adult striped bass.

6. Cesar Blanco (USFWS), Dan Welsh (USFWS), Rick Burmester (USFWS), J.D. Wikert (USFWS), Ramon Martin (USFWS), and Robert Evans (U.S. Bureau of Reclamation) provided useful comments as they reviewed portions of this report or provided technical advice.

SECTION 2: METHODS

2.1 OVERVIEW OF MONITORING LOCATIONS AND ACTIVITIES

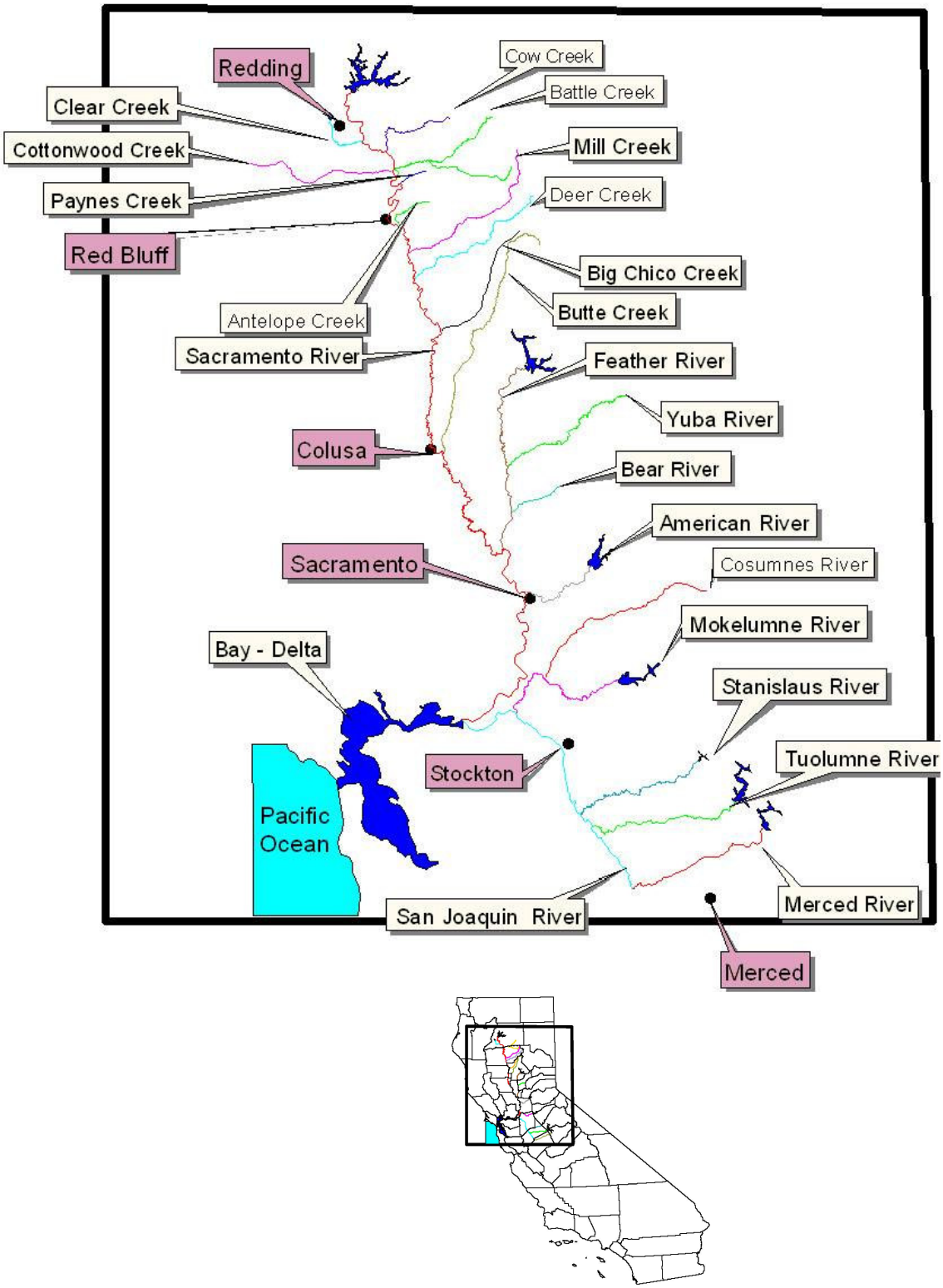
The watersheds and areas with an AFRP fish production target are depicted in Figure 2. Monitoring techniques used to assess the abundance of anadromous fish vary by taxa and are described in the 1997 CAMP Implementation Plan (Montgomery Watson et al. 1997). The techniques include, but are not limited to, carcass surveys, mark-recapture surveys, and ocean harvest surveys. Monitoring activities relating to AFRP fish production targets are focused on adult life stages of striped bass, white sturgeon, green sturgeon, and the four runs of Chinook salmon. Monitoring of American shad focuses on the juvenile life stage.

Every CAMP-recommended monitoring activity in a given watershed may not occur each year. For example, an estimate of the production of adult fall-run Chinook salmon from the American River should be quantified using: (1) carcass counts, (2) marking of hatchery-produced fish to develop a ratio of natural- vs. hatchery-origin fish, (3) counts of salmon returning to the Nimbus Salmon and Steelhead Hatchery, (4) surveys to quantify in-river angler harvest, and (5) assessments of the harvest of Chinook salmon in the Pacific Ocean. In reality, estimates of production of salmon from this watershed include census-derived data (e.g., carcass counts, counts of fish returning to the hatchery, and estimates of ocean harvest) and approximations that reflect best professional judgments (e.g., an estimate of the ratio of natural- vs. hatchery-origin fish and the amount of in-river angler harvest).

2.2 METHODS FOR ESTIMATING PRODUCTION OF ADULT CHINOOK SALMON

Calculations to estimate natural production of each run of Chinook salmon from each watershed include up to four components: (1) in-river spawner abundance (i.e., escapement), (2) hatchery returns, (3) in-river harvest by anglers, and (4) ocean harvest. In-river spawner abundance is quantified using carcass surveys, ladder counts, weir counts, snorkel surveys, and aerial redd counts. Hatchery returns are quantified by counting the number of salmon that enter fish hatcheries; production estimates for watersheds that do not have a fish hatchery will not include this component. Surveys to measure in-river harvest by anglers have not occurred on a consistent basis. The amount of in-river harvest used to calculate Chinook salmon production is therefore based on best professional judgments of angler harvest developed by fishery biologists. Ocean harvest is quantified by monitoring the number of Chinook salmon captured by commercial and recreational boats; the values are reported by the Pacific Fisheries Management Council (PFMC). CAMP annual reports use PFMC ocean harvest data that reflect commercial and recreational catches from boats in the Monterey and San Francisco Bay areas. This report does not therefore reflect ocean harvest of Central Valley Chinook salmon from boats based in Crescent City, Eureka, and Fort Bragg.

Figure 2. Watersheds and areas in the Central Valley that possess AFRP fish production targets. Map does not include the 7 "miscellaneous creeks" described in section 3.1.1.16 of this report. Red labels pertain to cities and yellow labels pertain to watershed names.



Collectively, the sum of the four components are used to estimate the total Chinook salmon production for a particular salmon run and watershed. To calculate the natural production for a particular salmon run and watershed, the watershed-specific total production estimate for a given run is then multiplied by an estimated hatchery proportion, i.e., the estimated ratio of natural- vs. hatchery-origin salmon of a given run in that watershed. This estimate reflects best professional judgments by fisheries biologists because empirical data for each watershed's hatchery proportion is not currently available. Figure 3 provides an illustration demonstrating how the natural production of Chinook salmon for different runs in each watershed is calculated.

This report uses the following references to develop Chinook salmon production estimates: (1) a "CopyPermitted_Grandtab.2009.02.18.pdf" file prepared by the CDFG; (2) a "Chinookprod 043009version2.xls" spreadsheet prepared by the AFRP; and (3) commercial and recreational salmon harvest data summarized in the *Review of 2008 Ocean Salmon Fisheries* (PFMC 2009).

2.3 METHODS FOR ASSESSING CHANGE IN ADULT CHINOOK SALMON POPULATIONS

This report uses three tools to assess the overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to CVPIA Section 3406(b) in meeting the AFRP fish production targets:

1. Enumerating the number of years the estimated annual production of Chinook salmon met or exceeded the AFRP's watershed-specific, run-specific, and Central Valley-wide production targets since 1991;

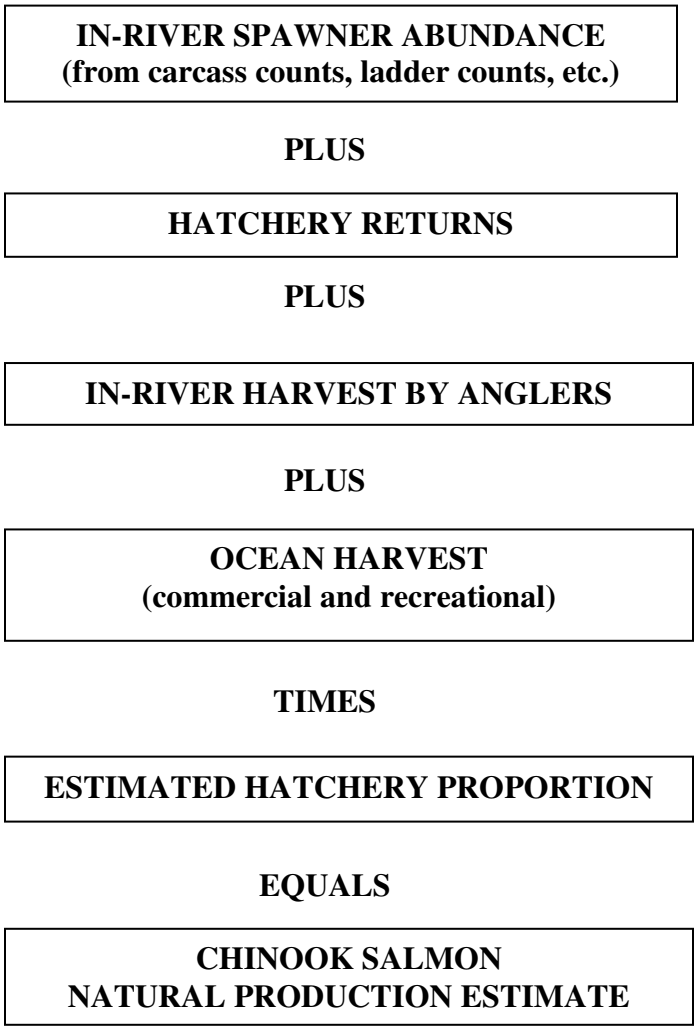
2. Determining the percent change in the average natural production of adult Chinook salmon in the 22 aforementioned watersheds between the 1967-1991 and 1992-2008 time periods; and

3. Using a Mann Whitney U test to determine if there is a statistically significant ($\alpha = 0.05$) difference in the average natural production of adult Chinook salmon from each watershed between the 1967-1991 and 1992-2008 time periods. As such, this test was used to evaluate the following null hypothesis:

   H_0: the average natural production of different Chinook salmon runs in different watersheds are the same in the 1967-1991 and 1992-2008 time periods.

The 2007 and 2008 CAMP annual reports also assessed the cumulative effectiveness of habitat restoration actions using the Pacific Salmon Commission's rebuilding assessment methods. For the sake of brevity, this method will not be used in the 2009 CAMP annual report to assess the cumulative effectiveness of habitat restoration actions.

Figure 3. Components used to calculate natural production of each run of adult Chinook salmon in 22 Central Valley watersheds.



2.4 METHODS FOR ESTIMATING PRODUCTION OF NON-SALMONID TAXA

2.4.1 METHODS FOR ADULT WHITE AND GREEN STURGEON

The AFRP production target for white sturgeon pertains to the number of 15-year-old white sturgeon in San Pablo and Suisun bays.

The production of white sturgeon ≥ 40 inches in total length in San Pablo and Suisun bays is estimated using mark-recapture data collected by the CDFG. Prior to 2005, the CDFG normally collected mark-recapture data for white sturgeon in two consecutive years, followed by a two year period when mark-recapture data were not collected. Since 2005, the CDFG has conducted white sturgeon surveys every year to develop more robust population estimates for the post-2005 period. Trammel nets are used to collect the mark-recapture data between August and early November. Captured sturgeon are marked with tags that have unique numbers, their length is measured, and they are then released. Subsequent efforts collect marked and unmarked sturgeon and provide the data to develop population estimates. A Bailey's modified Peterson model is used to estimate abundance of white sturgeon ≥ 40 inches in total length, irrespective of age. A length-age key provides an estimate of the proportion of the population that is 15-years-old. The estimate of the number of 15-year-old white sturgeon in San Pablo and Suisun bays in a given year is calculated by multiplying the annual production estimates of white sturgeon ≥ 40 inches in total length by the corresponding estimated fraction of the population believed to be 15-years-old.

Trammel net surveys in San Pablo and Suisun bays can also be used to monitor the abundance of green sturgeon. As surveys for white sturgeon are conducted, the number of green sturgeon that are incidentally caught is also tabulated. Production of green sturgeon in a given year is calculated by dividing the annual production estimate of white sturgeon ≥ 40 inches in total length by the ratio of white sturgeon to green sturgeon caught that year, i.e., abundance of green sturgeon ≥ 40 inches in length = abundance of white sturgeon ≥ 40 inches in length * (number of captured green sturgeon ≥ 40 inches in length / number of captured white sturgeon ≥ 40 inches in length). The estimate of green sturgeon production is therefore indexed to the total production of white sturgeon ≥ 40 inches in total length, and is not related to the estimated number of 15-year-old white sturgeon.

This report uses the following CDFG spreadsheets to develop white sturgeon production estimates: (1) a "CUMPOP_MD2a.xls" file dated March 13, 2007; and (2) a "WSTALKEY.xls" file dated December 22, 2006. The CDFG spreadsheets that provided length-frequency information used to develop population estimates for green sturgeon include: (1) a "WST_length_1990-2006.xls" file dated June 6, 2007; and (2) a "qry_Length_GST_ALL.xls" file dated June 1, 2007. At the time this report was prepared, the CDFG had not released sturgeon data that were collected after 2005.

2.4.2 METHODS FOR JUVENILE AMERICAN SHAD

Unlike the other seven fish taxa described in this report, changes in the abundance of American shad are indexed to a juvenile, i.e., young-of-the-year (YOY), age class instead of an adult age class. A midwater trawl (MWT) survey provides data to estimate the juvenile abundance index for American shad.

The CDFG conducts the MWT survey four months each year, i.e., in September, October, November, and December. The CDFG did not conduct MWT surveys in 1974, September and December of 1976, and 1979.

The MWT survey is conducted in a region encompassing the Sacramento-San Joaquin River Delta, San Pablo Bay, and Suisun Bay. Within this region, the MWT surveys are conducted in 17 different areas. Within these 17 areas, a series of "core index stations" exist. The core index stations used to estimate the juvenile American shad abundance index in this report are 303, 305-316, 321-340, 401-418, 501-519, 601-608, 701-711, 802, 804, 806-815, and 901-915.

For each month when the MWT survey is conducted, catches of American shad within each area are summed and an average catch per tow is calculated. "The average catch per tow for each area is then weighted by the water volume (thousands of acre feet) in that area. The weighted catches are summed over all areas. This sum is the survey index and it includes American shad of all ages (YOY, 1-, 2-, and 3-year old fish).

As American shad are collected during the MWT survey, the length of the majority of the captured shad are measured; these data can be used to determine the proportion of shad less than 1-year old, i.e., fish that are in the YOY age class. Because the AFRP production target for American shad is limited to the YOY abundance index, the CAMP has prorated the CDFG's all-ages abundance index by the proportion of fish in the YOY age class. Text in Appendix B provides additional information on the procedure to transform the annual all-ages abundance index to an index limited to the YOY age class. The 2007 and 2008 CAMP annual reports did not rely on a length frequency correction factor to transform CDFG's all-ages abundance index to the number of juvenile shad in the YOY age class. In this 2009 CAMP annual report, a length frequency correction factor is used to calculate the number of fish in the YOY age class because this factor adjusts for instances when every shad in a trawl was not measured according to length; this length frequency correction factor is likely to lead to more accurate estimations of the number of YOY American shad caught each year (D. Contreras, CDFG, pers. comm., 11/3/2009).

The raw data used to develop American shad production estimates in this report are contained in two references: (1) an "AMESHA FMWT Indices 1967-2008.xls" spreadsheet dated September 2, 2009; and (2) an "AMS Length Frequency 1971-2008.xls" spreadsheet dated November 3, 2009.

2.4.3 METHODS FOR ADULT STRIPED BASS

The CDFG monitors abundance of "legal-size" adult striped bass in the Sacramento-San Joaquin River Delta, the portion of the Sacramento River downstream from the town of Colusa, and the portion of the San Joaquin River downstream from the town of Mossdale. The length of legal-size fish has changed over time. Prior to 1982, legal-size striped bass were considered to be 16 or more inches in length. From 1982 to the present time, legal-size striped bass have been considered to be 18 or more inches in length.

A mark-recapture technique is used to monitor abundance of legal-size striped bass. The CDFG uses gill nets and fyke traps to collect striped bass from early April to mid-June. These collections usually occur each year. Nets and traps collect striped bass between Broad Slough and Colusa on the Sacramento River, and between Broad Slough and Venice Island on the San Joaquin River. As fish are collected they are measured, tagged with individually numbered disc-dangler tags, and released. The CDFG conducts creel surveys on a year-round basis each year to monitor the number and proportion of marked and unmarked striped bass. These creel censuses occur between the Pacific Ocean and Colusa on the Sacramento River, and between the Pacific Ocean and Mossdale on the San Joaquin River. A Bailey's modified Peterson model is used to estimate production of adult striped bass using the mark-recapture data.

A "DRAFT_ASB_ABUNDACEUPDATES.xls" spreadsheet provides the production estimates for striped bass in this report. This spreadsheet was provided to the CAMP by Jason DuBois of the CDFG on September 21, 2009.

SECTION 3: RESULTS

3.1 PRODUCTION ESTIMATES FOR ADULT CHINOOK SALMON

Because adult Chinook salmon data collected in 2007 and 2008 are subject to revision and refinement, salmon production estimates and any analyses for these years should be considered provisional. Annual production estimates for individual watersheds, runs, and the Central Valley are tabulated in Appendix A. The presence of a fish hatchery in a watershed confounds the ability to monitor natural production of Chinook salmon because it is not always possible to accurately discriminate between, and therefore count, wild salmon and unmarked hatchery salmon.

3.1.1 PRODUCTION ESTIMATES FOR INDIVIDUAL WATERSHEDS

3.1.1.1 AMERICAN RIVER

The Nimbus Fish Hatchery occurs in the American River watershed. It produces fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the American River between 1992 and 2008 are presented in Table 3 and Figure 4. The AFRP production target for fall-run Chinook salmon from the American River is 160,000 salmon. Estimated natural production of this run of Chinook salmon from this watershed exceeded the AFRP production target six times between 1992 and 2008.

3.1.1.2 ANTELOPE CREEK

Monitoring data that can be used to estimate the production of fall-run Chinook salmon from Antelope Creek have not been collected in any year between 1992 and 2008. It is therefore not possible to determine if the AFRP production target of 720 salmon was met in this watershed during that period.

3.1.1.3 BATTLE CREEK

The Coleman National Fish Hatchery occurs within the Battle Creek watershed. It produces fall- and late-fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from Battle Creek between 1992 and 2008 are presented in Table 3 and Figure 4. The AFRP production target for fall-run Chinook salmon from Battle Creek is 10,000 salmon. Estimated natural production of this run of Chinook salmon from this watershed exceeded the AFRP production target 13 times between 1992 and 2008.

Table 3. Estimated natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from 22 watersheds in the Central Valley, 1992-2008. Blank cells represent years when data were not collected for a particular run and location. * indicates a fish hatchery is present in the watershed.

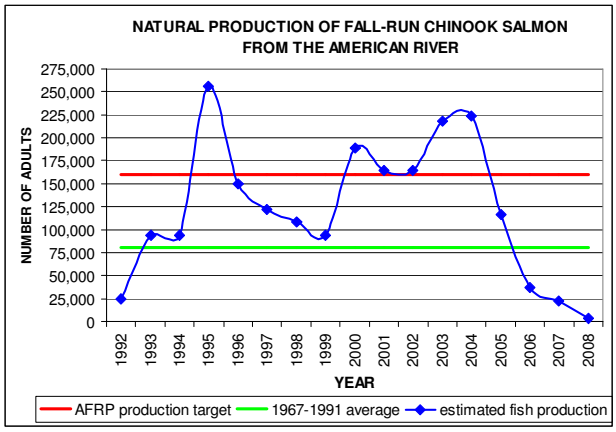
Taxa	YEAR																
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Fall-run Chinook salmon																	
American River*	25,138	93,912	94,218	255,608	149,509	121,699	108,096	93,810	189,444	164,627	164,529	218,491	223,627	116,745	36,402	22,242	3,556
Antelope Creek																	
Battle Creek*	3,586	5,610	12,857	30,968	16,883	26,978	20,178	21,845	16,324	17,780	71,890	23,669	20,728	30,345	11,289	4,181	1,493
Bear River																	
Big Chico Creek																	
Butte Creek				1,347	931	1,682	824			5,018	4,534	4,311	4,540	6,333	2,237	1,893	220
Clear Creek	1,358	3,017	6,049	27,699	10,875	18,247	6,990	11,659	11,648	12,302	19,950	11,718	11,456	22,090	9,806	6,367	6,142
Cosumnes River							623								771	102	
Cottonwood Creek	3,575															1,929	160
Cow Creek															4,809	3,155	160
Deer Creek		176	737			2,580	451						545	1,401	2,215	784	155
Feather River*	77,632	93,845	111,323	188,771	107,612	120,719	34,440	19,870	194,181	192,269	131,895	114,983	117,376	88,527	87,175	37,714	8,777
Merced River*	2,396	4,350	9,172	9,303	8,734	8,350	7,226	7,472	24,398	13,174	14,272	4,088	8,369	4,057	2,029	954	565
Mill Creek	2,262	4,760	2,568			1,018	907				3,238	2,992	2,132	3,614	1,632	1,228	133
"miscellaneous creeks"																215	16
Mokelumne River*	2,782	5,706	5,641	12,304	10,892	16,254	8,888	5,822	9,668	6,822	10,018	9,507	16,125	18,047	5,127	1,758	227
Paynes Creek																	
Sacramento River mainstem	54,554	83,571	104,396	142,805	115,735	190,422	7,786	176,206	126,080	63,793	61,156	82,793	58,887	63,760	48,430	19,741	15,118
Stanislaus River	695	1,946	2,924	2,243	365	14,224	6,041	7,579	17,614	9,501	11,533	8,726	8,627	5,898	2,671	817	1,305
Tuolumne River	362	1,342	1,430	2,959	9,536	18,169	17,461	14,319	37,063	11,862	10,637	3,193	4,239	1,288	866	411	455
Yuba River	17,938	20,188	32,370	53,001	64,014	69,033	63,823	44,155	32,561	33,085	37,325	43,792	34,342	32,116	11,981	5,025	3,613
Total	192,277	318,422	383,686	727,008	495,086	609,375	283,734	402,737	658,981	530,233	540,977	528,262	510,992	394,220	227,441	108,516	42,094

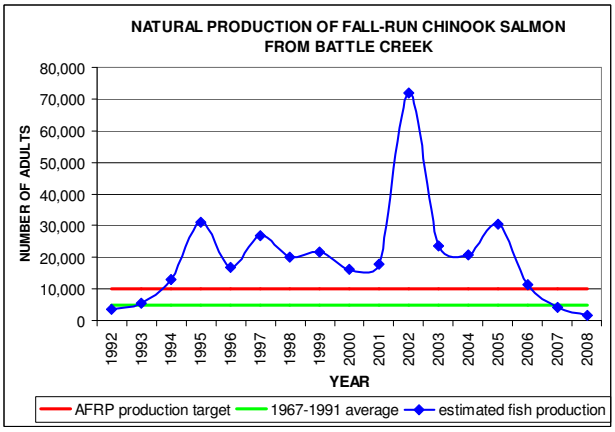
Table 3 (cont.). Estimated natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from 22 watersheds in the Central Valley, 1992-2008. Blank cells represent years when data were not collected for a particular run and location. * indicates a fish hatchery is present in the watershed.

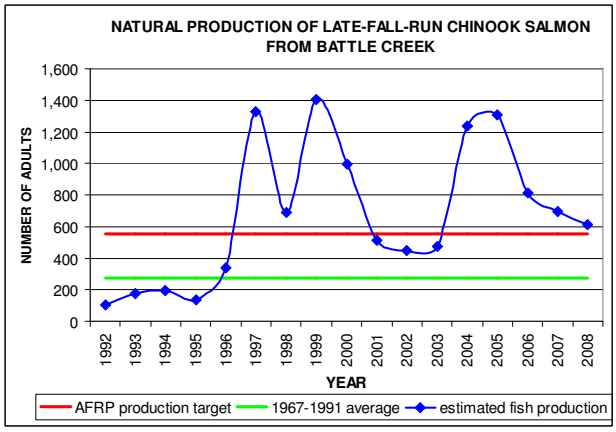
Taxa	YEAR																
	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Late-fall run Chinook salmon																	
Battle Creek *	106	174	195	134	336	1,330	690	1,406	994	514	452	472	1,236	1,309	811	698	614
Sacramento River mainstem	27,652	2,237	869	630	111		80,866	15,838	19,040	27,313	55,957	8,512	19,874	19,794	14,819	29,803	4,292
Total	27,758	2,411	1,063	764	447	1,330	81,556	17,243	20,034	27,826	56,409	8,984	21,111	21,103	15,629	30,501	4,906
Winter-run Chinook salmon																	
Calaveras River																	
Sacramento River mainstem*	3,167	1,024	506	4,079	2,112	2,010	5,579	5,439	2,659	10,572	10,508	11,552	16,101	26,915	22,894	4,451	2,850
Total	3,167	1,024	506	4,079	2,112	2,010	5,579	5,439	2,659	10,572	10,508	11,552	16,101	26,915	22,894	4,451	2,850
Spring-run Chinook salmon																	
Butte Creek	2,061	1,951	1,412	27,913	3,235	1,702	41,579	6,695	8,943	13,592	13,637	6,799	16,641	19,801	6,663	9,533	3,935
Deer Creek	590	778	1,444	4,820	1,406	1,249	3,856	2,895	1,383	2,295	3,392	4,265	1,811	4,173	3,539	1,242	140
Mill Creek	669	183	2,154	1,191	579	541	869	1,019	1,181	1,557	2,474	2,204	2,247	2,143	1,458	1,774	362
Sacramento River mainstem	1,143	1,280	2,801	1,729	944	374	2,497	520	168	1,136	463	0	968	61	0	522	
Total	4,463	4,193	7,811	35,654	6,165	3,866	48,802	11,130	11,676	18,581	19,966	13,269	21,667	26,178	11,659	13,071	4,437
Total Natural Production of Adult Chinook Salmon	227,664	326,050	393,066	767,505	503,810	616,581	419,671	436,549	693,349	587,213	627,860	562,067	569,871	468,416	277,624	156,539	54,288

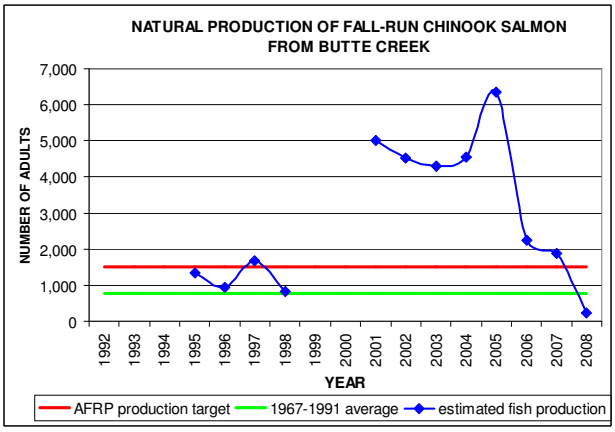
blank cells represent periods when data were not collected for a particular run and location

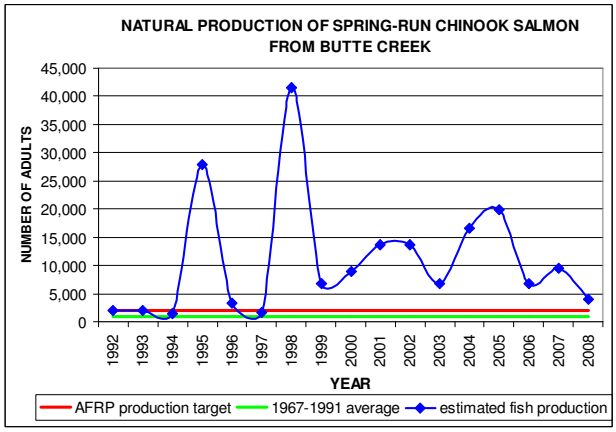
Figure 4. Estimated natural production of adult Chinook salmon from the American River, Battle Creek, Butte Creek, and Clear Creek, 1992-2008. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2008, and average natural production of Chinook salmon between 1967 and 1991.

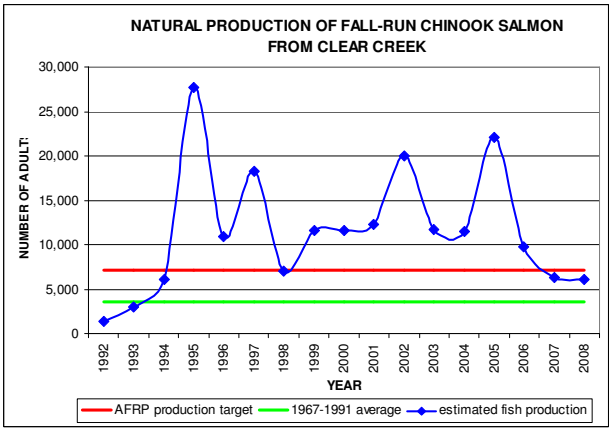












Estimates of natural production of adult late-fall-run Chinook salmon from Battle Creek during the period 1992-2008 are presented in Table 3 and Figure 4. The AFRP production target for adult late-fall-run Chinook salmon from Battle Creek is 550 salmon. Estimated natural production of this run of Chinook salmon from this watershed may have exceeded the AFRP production target nine times between 1992 and 2008.

The inference of the number of times the AFRP production target for late-fall-run Chinook salmon from Battle Creek is confounded by multiple factors. First, the Chinookprod spreadsheet used to develop production estimates are based solely on counts of adult (and predominantly hatchery-origin) salmon returning to the hatchery and no in-river escapement estimates of wild salmon are available. There are, therefore, no definitive monitoring data that can be used to infer what the natural production of adult late-fall-run Chinook salmon from Battle Creek is or has been. Second, a relatively small number (i.e., 6-213) of wild late-fall-run salmon entered Coleman National Fish Hatchery between 1998 and 2008 and were released upstream of the hatchery, thereby contributing to natural in-river escapement. These fish have not, however, been accounted for in the Chinookprod or GrandTab spreadsheets and therefore are not used to calculate or track natural production. Third, because the management practices for hatchery-origin late-fall-run Chinook salmon have improved since 1996, the number of these hatchery-produced fish has increased since that time.

3.1.1.4 BEAR RIVER

Monitoring data that can be used to estimate the production of fall-run Chinook salmon from Bear River have not been collected in any year between 1992 and 2008. It is therefore not possible to determine if the AFRP production target of 450 salmon was met in this watershed during that period.

3.1.1.5 BIG CHICO CREEK

Monitoring data that can be used to estimate the production of fall-run Chinook salmon from Big Chico Creek have not been collected in any year between 1992 and 2008. It is therefore not possible to determine if the AFRP production target of 800 salmon was met in this watershed during that period.

3.1.1.6 BUTTE CREEK

Estimates of natural production of adult fall-run Chinook salmon from Butte Creek between 1992 and 2008 are presented in Table 3 and Figure 4. Estimates of natural production are not available for 1992, 1993, 1994, 1999, and 2000. The AFRP production target for fall-run Chinook salmon from Butte Creek is 1,500 salmon. Estimated natural production of this run of Chinook salmon from this watershed exceeded the AFRP production target eight times in the 12 years when monitoring data were collected between 1992 and 2008.

Estimates of natural production of adult spring-run Chinook salmon from Butte Creek between 1992 and 2008 are presented in Table 3 and Figure 4. The AFRP production target for spring-

run Chinook salmon from Butte Creek is 2,000 salmon. Estimated natural production of this run of Chinook salmon from that watershed exceeded the AFRP production target 14 times between 1992 and 2008.

3.1.1.7 CALAVERAS RIVER

Monitoring data that can be used to estimate the production of winter-run Chinook salmon from the Calaveras River have not been collected in any year between 1992 and 2008. It is therefore not possible to determine if the AFRP winter-run Chinook salmon production target of 2,200 salmon was met in this watershed during that period.

3.1.1.8 CLEAR CREEK

Estimates of natural production of adult fall-run Chinook salmon from Clear Creek between 1992 and 2008 are presented in Table 3 and Figure 4. The AFRP production target for fall-run Chinook salmon from Clear Creek is 7,100 salmon. Estimated natural production of this run of Chinook salmon from that watershed exceeded the AFRP production target 11 times between 1992 and 2008.

3.1.1.9 COSUMNES RIVER

Estimates of natural production of adult fall-run Chinook salmon from Cosumnes River between 1992 and 2008 are presented in Table 3 and Figure 5. Monitoring data for Chinook salmon from the Cosumnes River have only been collected three times since 1991. The AFRP production target for fall-run Chinook salmon from the Cosumnes River is 3,300 salmon. The production target was not been met in the three years when monitoring data were collected since 1991.

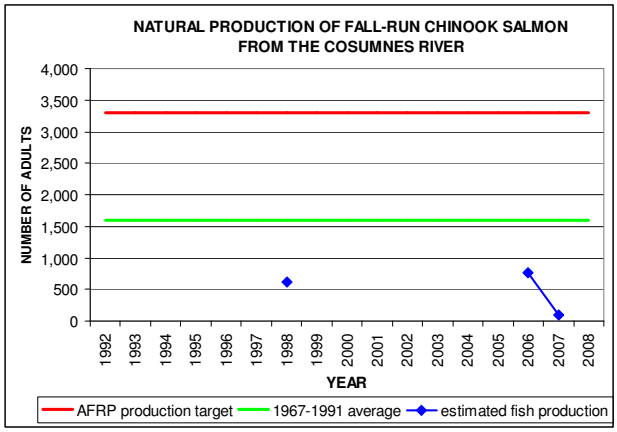
3.1.1.10 COTTONWOOD CREEK

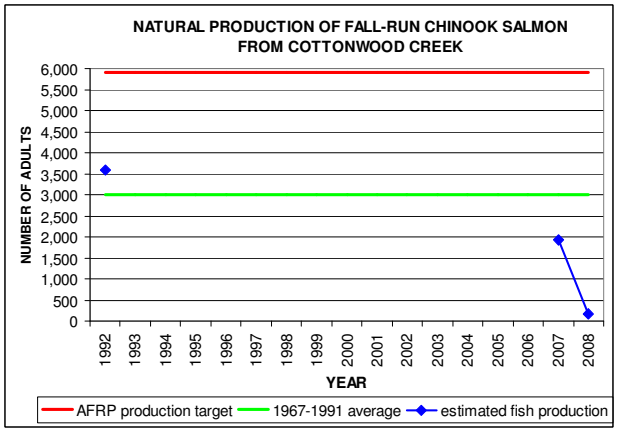
Estimates of natural production of adult fall-run Chinook salmon from Cottonwood Creek between 1992 and 2008 are presented in Table 3 and Figure 5. Monitoring data for Chinook salmon from Cottonwood Creek have only been collected three times since 1991. The AFRP production target for fall-run Chinook salmon from Cottonwood Creek is 5,900 salmon. The production target was not met in the three years when monitoring data were collected since 1991.

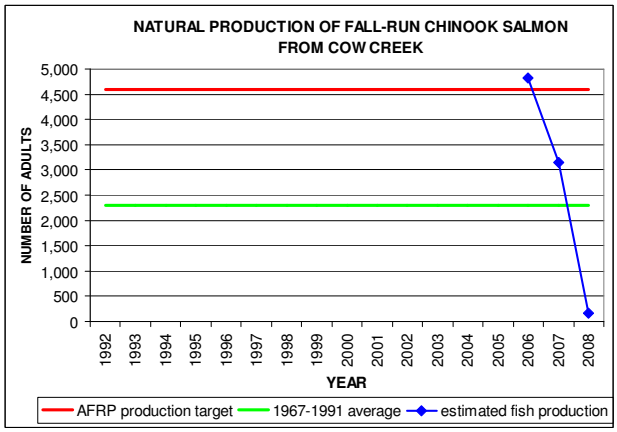
3.1.1.11 COW CREEK

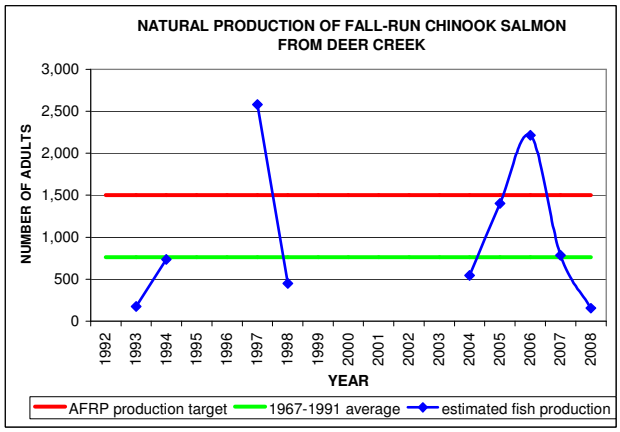
Estimates of natural production of adult fall-run Chinook salmon from Cow Creek between 1992 and 2008 are presented in Table 3 and Figure 5. Monitoring data for Chinook salmon from Cow Creek have only been collected three times since 1991. The AFRP production target for fall-run Chinook salmon from Cow Creek is 4,600 salmon. The AFRP production target was met in one of the three years when monitoring data were collected since 1991.

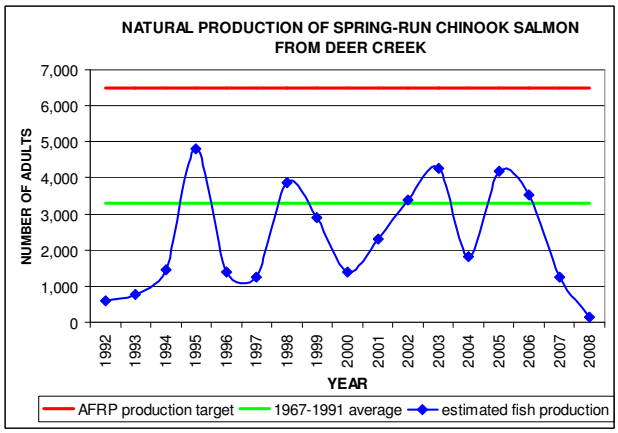
Figure 5. Estimated natural production of adult Chinook salmon from the Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, and the Feather River, 1992-2008. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2008, and average natural production of Chinook salmon between 1967 and 1991.

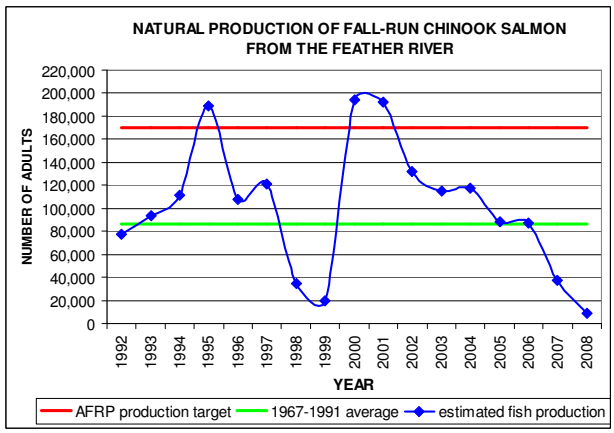












3.1.1.12 DEER CREEK

Estimates of natural production of adult fall-run Chinook salmon from Deer Creek between 1992 and 2008 are presented in Table 3 and Figure 5. Production estimates are not available for 1992, 1995, 1996, 1999, 2000, 2001, 2002, and 2003. The AFRP production target for fall-run Chinook salmon from Deer Creek is 1,500 salmon. Estimated natural production exceeded the AFRP production target twice in the nine years when monitoring data were collected between 1992 and 2008.

Estimates of natural production of adult spring-run Chinook salmon from Deer Creek between 1992 and 2008 are presented in Table 3 and Figure 5. The AFRP production target for adult spring-run Chinook salmon from Deer Creek is 6,500 salmon. Estimated natural production of adult spring-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2008.

3.1.1.13 FEATHER RIVER

The Feather River Fish Hatchery is located in the Feather River watershed. It produces fall- and spring-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the Feather River between 1992 and 2008 are presented in Table 3 and Figure 5. Prior to 2003, estimates of the number of fall-run Chinook salmon that returned to the hatchery included a combination of fall- and spring-run Chinook salmon because no simple method for distinguishing between the two runs existed. Beginning in 2003 and to the present time, spring-run Chinook salmon have been marked with floy tags and released back into the river so they can be distinguished from fall-run Chinook salmon as fall-run salmon return to hatchery. However, hatchery return numbers used to estimate natural production of fall-run Chinook salmon continue to include some spring-run Chinook salmon; this tends to inflate the fall-run production estimates to some degree because they include some spring-run Chinook salmon. Natural production estimates for 1998 and 1999 are anomalously low because carcass surveys were not used to estimate in-river spawner abundance, and those fish could not therefore be included in natural production estimates.

The AFRP production target for fall-run Chinook salmon from the Feather River is 170,000 salmon. Estimated natural production of adult fall-run Chinook salmon from this watershed equaled or exceeded this AFRP production target three times between 1992 and 2008, i.e., in 1995, 2000, and 2001.

3.1.1.14 MERCED RIVER

The Merced River Fish Hatchery is located in the Merced River watershed. It produces fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the Merced River between 1992 and 2008 are presented in Table 3 and Figure 6. The AFRP production target for

adult fall-run Chinook salmon from the Merced River is 18,000 salmon. Estimated natural production equaled or exceeded the AFRP production target once between 1992 and 2008.

3.1.1.15 MILL CREEK

Estimates of natural production of adult fall-run Chinook salmon from Mill Creek between 1992 and 2008 are presented in Table 3 and Figure 6. Estimates are not available for 1995, 1996, 1999, 2000, and 2001. The AFRP production target for fall-run Chinook salmon from Mill Creek is 4,200 salmon. Estimated natural production exceeded the AFRP production target once in the 12 years when monitoring data were collected since 1991.

Estimates of natural production of adult spring-run Chinook salmon from Mill Creek between 1992 and 2008 are presented in Table 3 and Figure 6. The AFRP production target for spring-run Chinook salmon from Mill Creek is 4,400 salmon. The estimated natural production of these fish from that watershed never equaled or exceeded the AFRP production target between 1992 and 2008.

3.1.1.16 MISCELLANEOUS CREEKS

The AFRP fish production target for the "miscellaneous creeks" includes the combined production from seven watersheds above the Red Bluff Diversion Dam. These watersheds are Spring Gulch, China Gulch, Olney Creek, Ash Creek, Stillwater Creek, Inks Creek, and Bear Creek (Rick Burmester, AFRP, pers. comm.). The combined production target for these watersheds only pertains to fall-run Chinook salmon. Between 1992 and 2006, the abundance of Chinook salmon was not monitored in any of the seven "miscellaneous creeks". In 2007 and 2008, the only "miscellaneous creek" above the Red Bluff Diversion Dam where monitoring for Chinook salmon took place was Bear Creek.

Estimates of the natural production of adult fall-run Chinook salmon from the one "miscellaneous creek" where monitoring took place between 1992 and 2008, i.e., Bear Creek, are presented in Table 3. A figure depicting the estimated production for the "miscellaneous creeks" is not presented in this report because six of the seven creeks are not monitored. The AFRP production target for fall-run Chinook salmon from the seven "miscellaneous creeks" above the Red Bluff Diversion Dam is 1,100 salmon. The natural production of fall-run Chinook salmon from the only "miscellaneous creek" that was monitored between 1992 and 2008 did not exceed the AFRP "miscellaneous creeks" production target in the two years when monitoring data were collected.

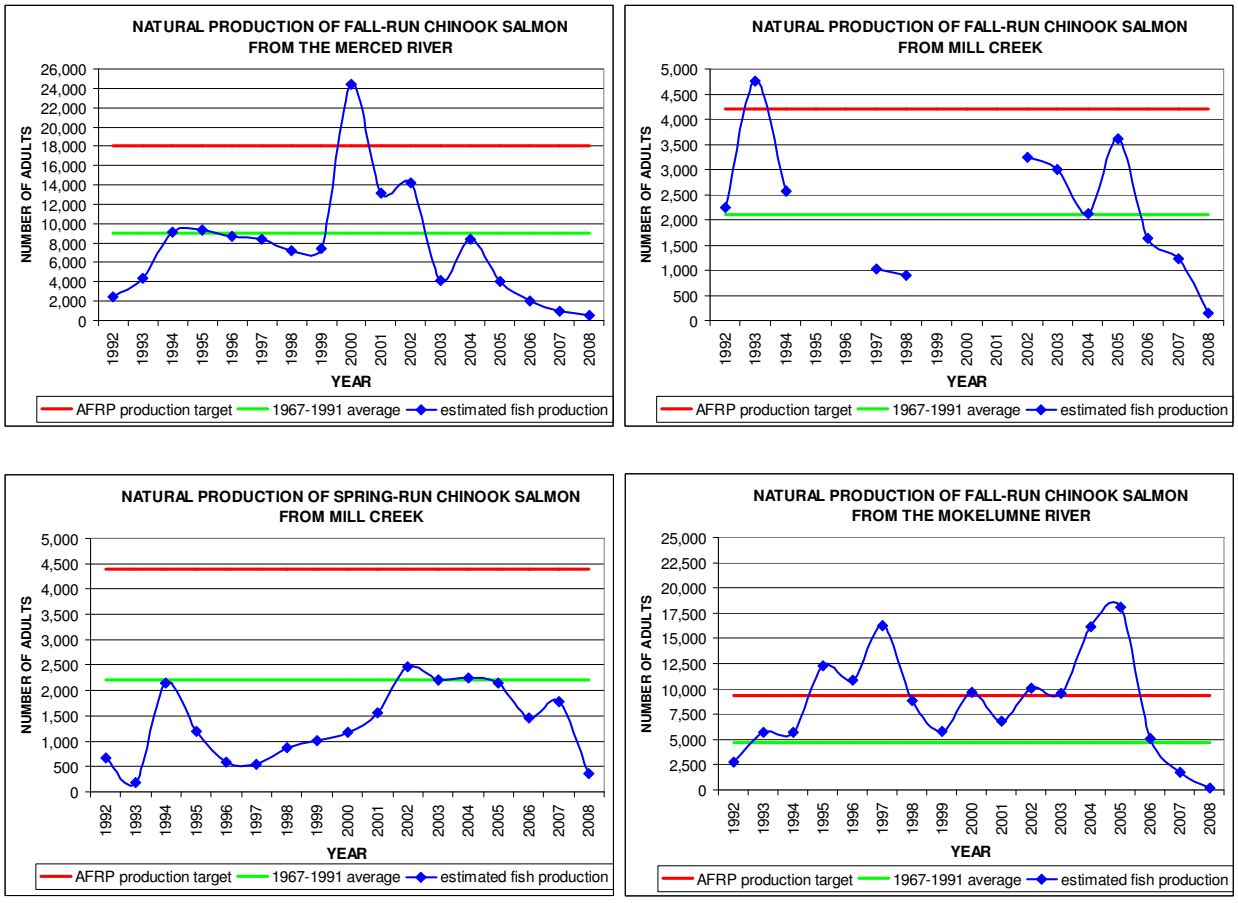
3.1.1.17 MOKELUMNE RIVER

The Mokelumne River Fish Hatchery is located in the Mokelumne River watershed. It produces fall-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the Mokelumne River between 1992 and 2008 are presented in Table 3 and Figure 6. The AFRP production target for

fall-run Chinook salmon on the Mokelumne River is 9,300 salmon. Estimated natural production equaled or exceeded this AFRP production target eight times between 1992 and 2008.

Figure 6. Estimated natural production of adult Chinook salmon from the Merced River, Mill Creek, and the Mokelumne River, 1992-2008. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2008, and average natural production of Chinook salmon between 1967 and 1991.



3.1.1.18 PAYNES CREEK

Monitoring data that can be used to estimate the production of fall-run Chinook salmon from Paynes Creek have not been collected in any year between 1992 and 2008. It is therefore not possible to determine if the AFRP production target of 330 salmon was met in this watershed during that period.

3.1.1.19 SACRAMENTO RIVER MAINSTEM

The Livingston Stone National Fish Hatchery is located in Sacramento River mainstem just below Shasta Dam. It produces winter-run Chinook salmon.

Estimates of natural production of adult fall-run Chinook salmon from the Sacramento River mainstem between 1992 and 2008 are presented in Table 3 and Figure 7. The AFRP production target for fall-run Chinook salmon from the Sacramento River is 230,000 salmon. Estimated natural production of this run of Chinook salmon from that watershed never equaled or exceeded the AFRP production target between 1992 and 2008.

Estimates of natural production of adult late-fall-run Chinook salmon between 1992 and 2008 are presented in Table 3 and Figure 7. The AFRP production target for late-fall-run Chinook salmon from the Sacramento River is 68,000 salmon. Estimated natural production exceeded the AFRP production target once between 1992 and 2008.

Estimates of natural production of adult winter-run Chinook salmon from the Sacramento River mainstem between 1992 and 2008 are presented in Table 3 and Figure 7. The AFRP production target for winter-run Chinook salmon from the Sacramento River is 110,000 salmon. Estimated natural production never equaled or exceeded the AFRP production target between 1992 and 2008.

Estimates of natural production of adult spring-run Chinook salmon from the Sacramento River mainstem between 1992 and 2008 are presented in Table 3 and Figure 7. Escapement estimates for this run in that watershed in 2003 and 2006 were zero because no spring-run Chinook salmon were known to spawn in the river those years. Since there is no hatchery for spring-run Chinook salmon in this watershed, the formulas in the Chinookprod spreadsheet used to estimate natural production generate a zero value for those years. At the time this report was produced, a production estimate for spring-run Chinook salmon from the Sacramento River mainstem was not available for 2008. The AFRP production target for spring-run Chinook salmon from the Sacramento River is 59,000 salmon. The estimated natural production of adult spring-run Chinook salmon from the Sacramento River never equaled or exceeded the AFRP production target between 1992 and 2007.

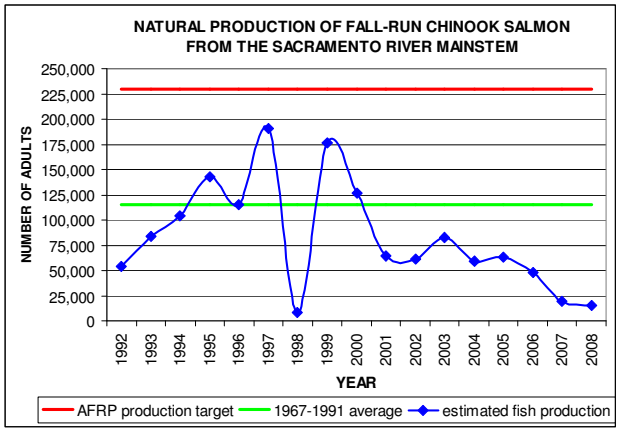
3.1.1.20 STANISLAUS RIVER

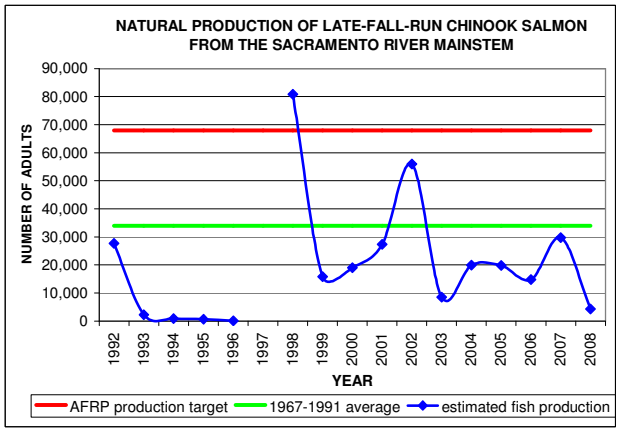
Estimates of natural production of adult fall-run Chinook salmon from the Stanislaus River between 1992 and 2008 are presented in Table 3 and Figure 7. The AFRP production target for fall-run Chinook salmon from the Stanislaus River is 22,000 salmon. The estimated natural production of adult fall-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2008.

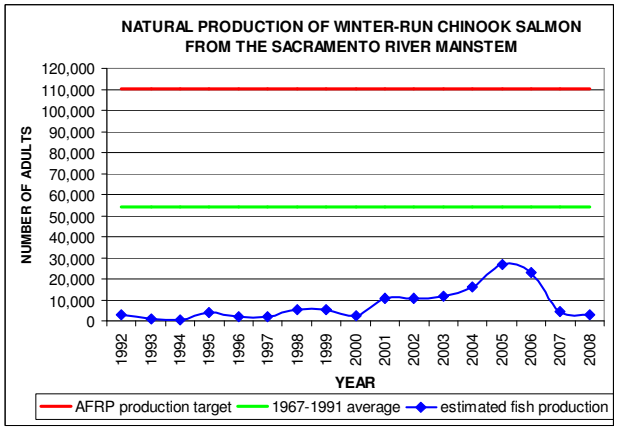
3.1.1.21 TUOLUMNE RIVER

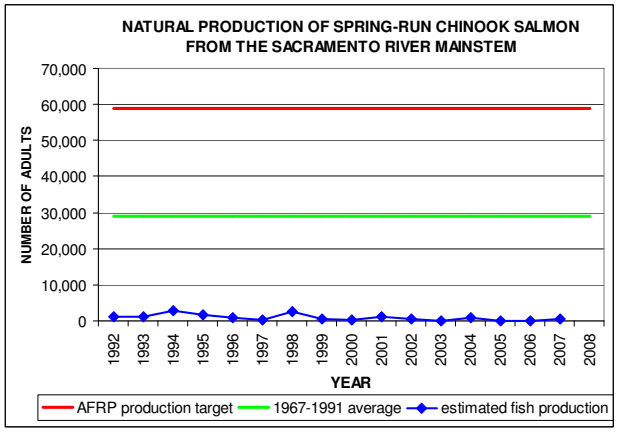
Estimates of natural production of adult fall-run Chinook salmon from the Tuolumne River between 1992 and 2008 are presented in Table 3 and Figure 7. The AFRP production target of fall-run Chinook salmon from the Tuolumne River is 38,000 salmon. Estimated natural production of adult fall-run Chinook salmon from this watershed never equaled or exceeded the AFRP production target between 1992 and 2008.

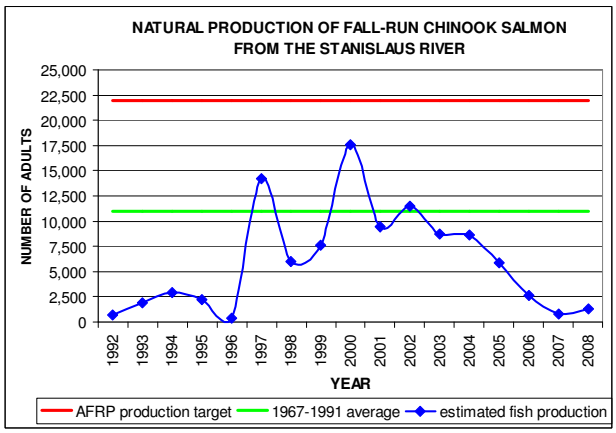
Figure 7. Estimated natural production of adult Chinook salmon from the Sacramento River, Stanislaus River, and Tuolumne River, 1992-2008. Each graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2008, and average natural production of Chinook salmon between 1967 and 1991.

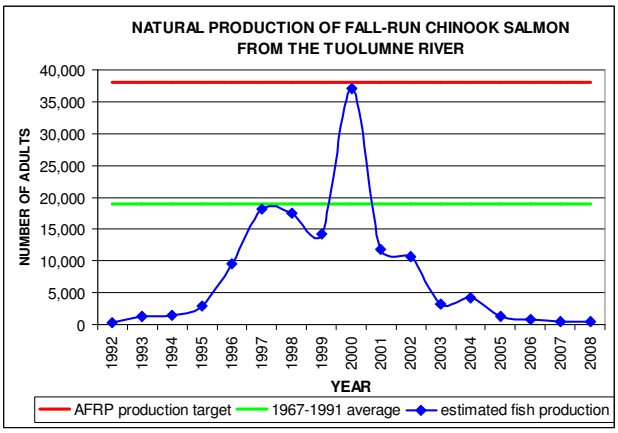








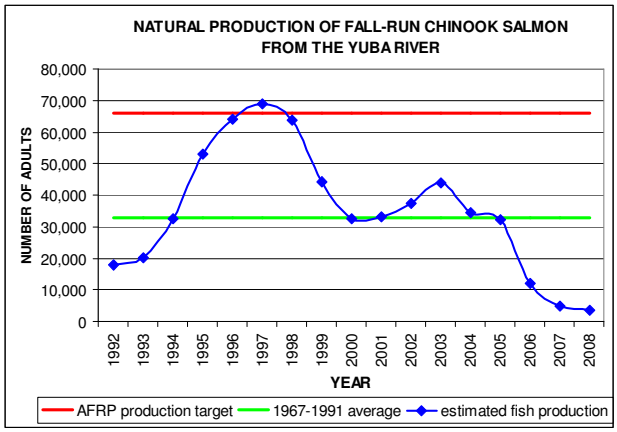




3.1.1.22 YUBA RIVER

Estimates of natural production of adult fall-run Chinook salmon from the Yuba River between 1992 and 2008 are presented in Table 3 and Figure 8. The AFRP production target of fall-run Chinook salmon from the Yuba River is 66,000 salmon. Estimated natural production of adult fall-run Chinook salmon from this watershed equaled or exceeded the AFRP production target one year between 1992 and 2008.

Figure 8. Estimated natural production of adult Chinook salmon from the Yuba River, 1992-2008. The graph provides the watershed's AFRP production target, estimated annual natural production of Chinook salmon between 1992 and 2008, and average natural production of Chinook salmon between 1967 and 1991.



3.1.2 PRODUCTION ESTIMATES FOR INDIVIDUAL RUNS

The production estimates for each of the four runs below only include fish abundance estimates from watersheds and runs having an AFRP fish production target. Therefore, the spring-run production estimates only include fish from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem, and do not include salmon from other watersheds where spring-run Chinook salmon occur, e.g., Antelope, Battle, Big Chico, Clear, Cottonwood, and Thomes creeks, or the Feather or Yuba rivers.

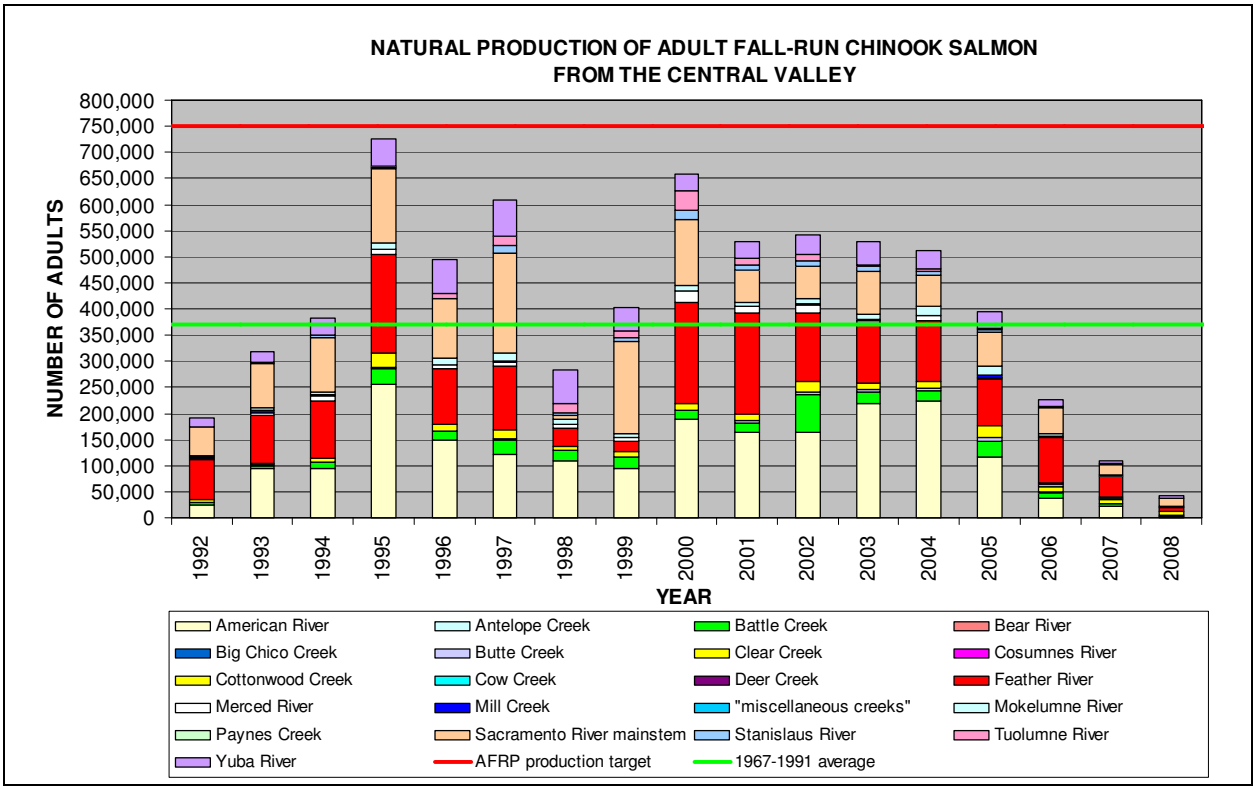
3.1.2.1 FALL-RUN CHINOOK SALMON

Estimates of the natural production of adult fall-run Chinook salmon from the Central Valley between 1992 and 2008 are presented in Table 3 and Figure 9. The estimates include the combined contributions from the aforementioned 21 watersheds with an AFRP fall-run production target. The AFRP production target for adult fall-run Chinook salmon from the 21 watersheds in the Central Valley is 750,000 salmon. Salmon surveys in the Central Valley between 1992 and 2008 suggest the combined natural production of adult fall-run Chinook

salmon from the 21 watersheds never equaled or exceeded this production target during that period.

Between 1992 and 2008 and in descending order based on their average annual natural production during this period, the following watersheds consistently contributed the greatest number of fall-run Chinook salmon to the AFRP production target: American River, Feather River, Sacramento River mainstem, Yuba River, and Battle Creek.

Figure 9. Estimated natural production of adult fall-run Chinook salmon from the Central Valley, 1992-2008. Annual estimates of natural production reflect the combined contributions from 21 watersheds. The AFRP fall-run Chinook salmon production target is 750,000 Chinook salmon, and the 1967-1991 baseline average is 374,064 Chinook salmon.

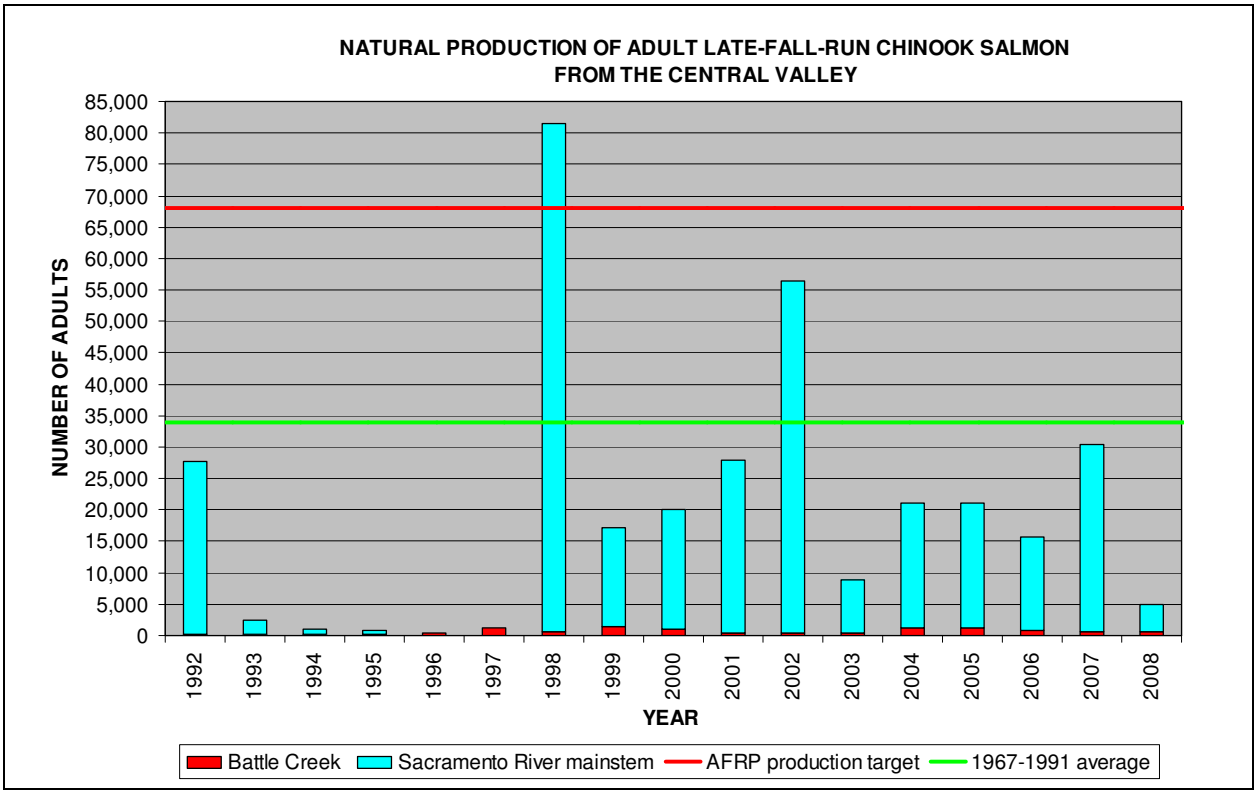


3.1.2.2 LATE-FALL-RUN CHINOOK SALMON

Estimates of the natural production of adult late-fall-run Chinook salmon from the Central Valley between 1992 and 2008 are presented in Table 3 and Figure 10. These production estimates include contributions from Battle Creek and the Sacramento River mainstem. The AFRP production target for adult late-fall-run Chinook salmon is 68,000 salmon. Fish surveys indicate the combined natural production of adult late-fall-run Chinook salmon from Battle

Creek and the Sacramento River mainstem met this production target once during that 17-year period (i.e., in 1998).

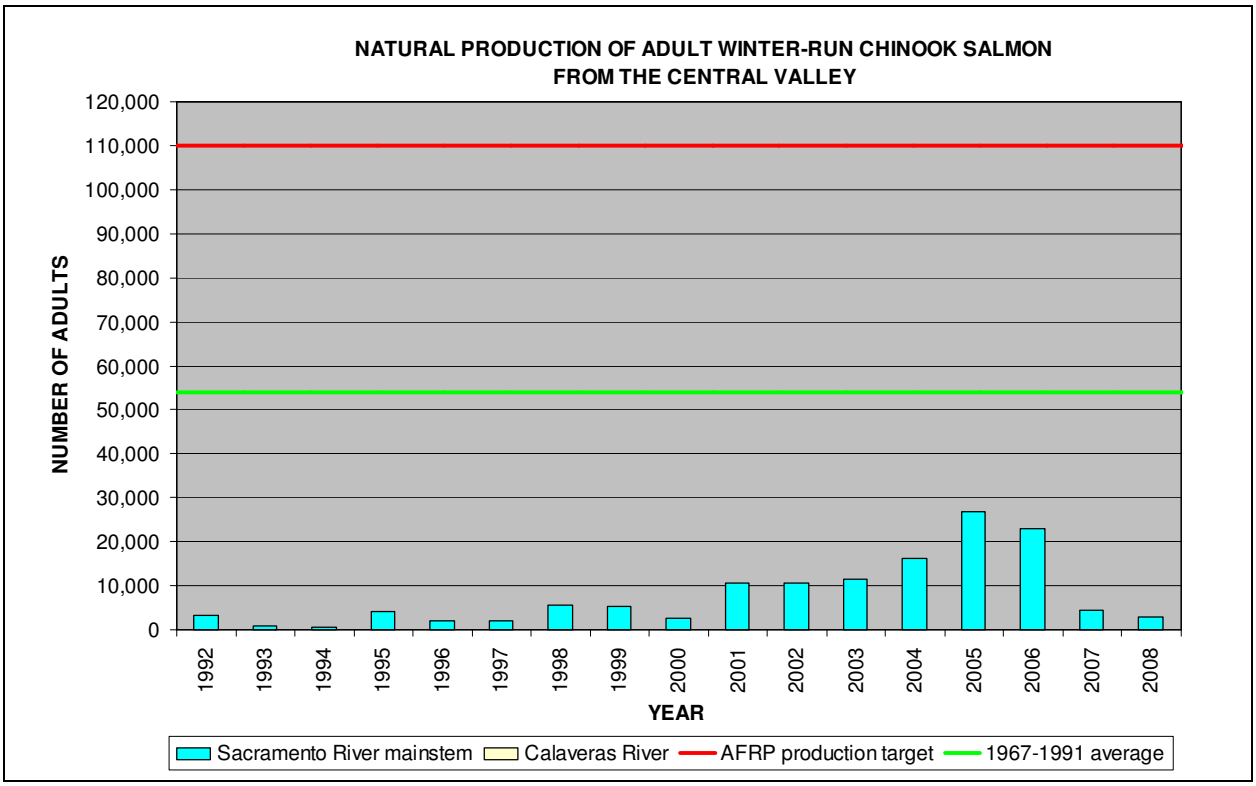
Figure 10. Estimated natural production of adult late-fall-run Chinook salmon from the Central Valley, 1992-2008. Annual estimates reflect the combined contributions from the Sacramento River mainstem and Battle Creek. The AFRP late-fall-run Chinook salmon production target is 68,000 Chinook salmon, and the 1967-1991 baseline average is 34,192 Chinook salmon.



3.1.2.3 WINTER-RUN CHINOOK SALMON

Estimates of the natural production of adult winter-run Chinook salmon from the Central Valley between 1992 and 2008 are presented in Table 3 and Figure 11. These production estimates consist of contributions from the Sacramento River mainstem and the Calaveras River. Surveys in the latter river have not been done since 1991, so there was not opportunity for this river to contribute to the winter-run Chinook salmon production target. The AFRP production target for adult winter-run Chinook salmon is 110,000 salmon. Chinook salmon surveys indicate the winter-run Chinook salmon production target between 1992 and 2008 was never met because: (1) the winter-run Chinook salmon production from the Sacramento River mainstem since 1992 has been markedly below the AFRP's winter-run Chinook salmon production target, and (2) the winter-run Chinook salmon production from the Calaveras River historically was too small to contribute to the AFRP winter-run Chinook salmon production target in a substantial way.

Figure 11. Estimated natural production of adult winter-run Chinook salmon from the Central Valley, 1992-2008. Annual estimates reflect the combined contributions from the Sacramento River mainstem and the Calaveras River. The AFRP winter-run Chinook salmon production target is 110,000 Chinook salmon, and the 1967-1991 baseline average is 54,439 Chinook salmon.

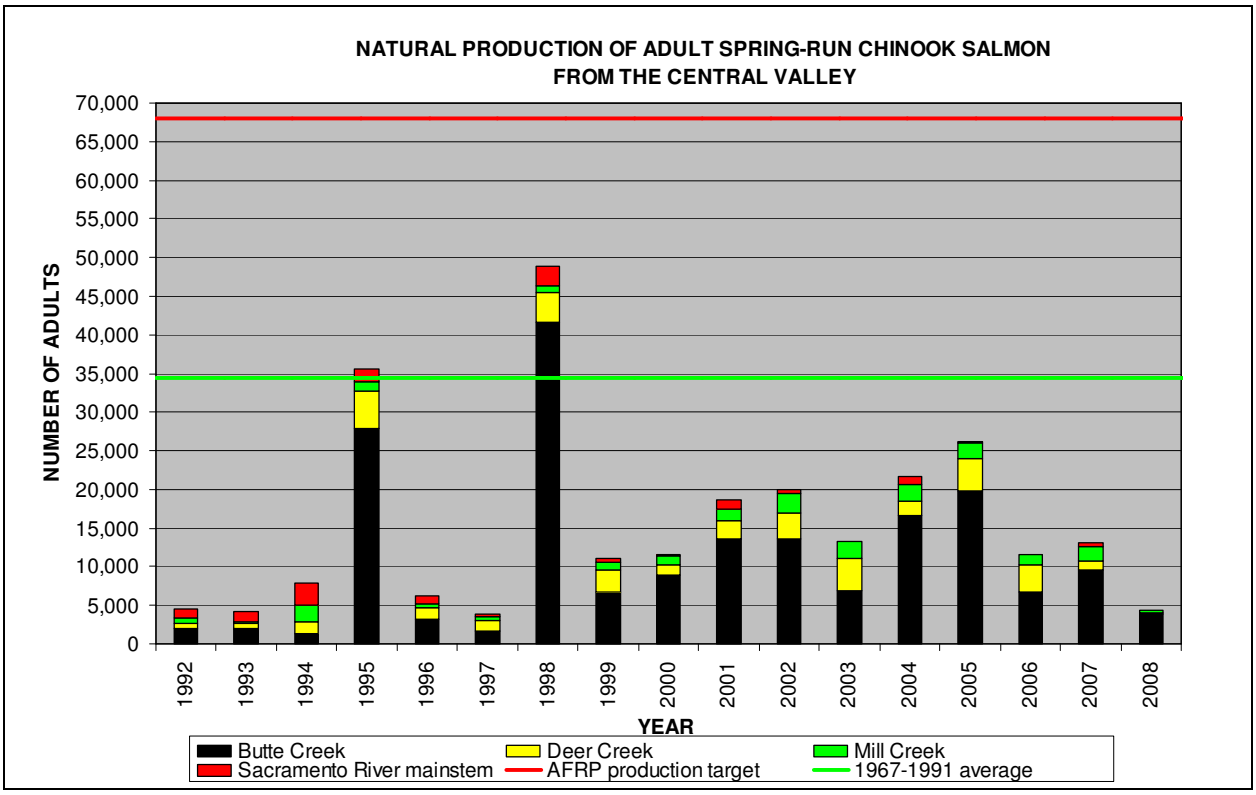


3.1.2.4 SPRING-RUN CHINOOK SALMON

Estimates of the natural production of adult spring-run Chinook salmon in the Central Valley between 1992 and 2008 are presented in Table 3 and Figure 12. The estimates include the combined contributions from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem. The AFRP production target for adult spring-run Chinook salmon is 68,000 salmon. Surveys between 1992 and 2008 suggest the combined natural production of adult spring-run Chinook salmon from the four watersheds never equaled or exceeded this production target during that period.

Butte Creek has routinely produced as many or more adult spring-run Chinook salmon as the other three watersheds combined.

Figure 12. Estimated natural production of adult spring-run Chinook salmon from the Central Valley, 1992-2008. Annual estimates reflect the combined contributions from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River mainstem. The AFRP spring-run Chinook salmon production target is 68,000 Chinook salmon, and the 1967-1991 baseline average is 34,374 Chinook salmon.

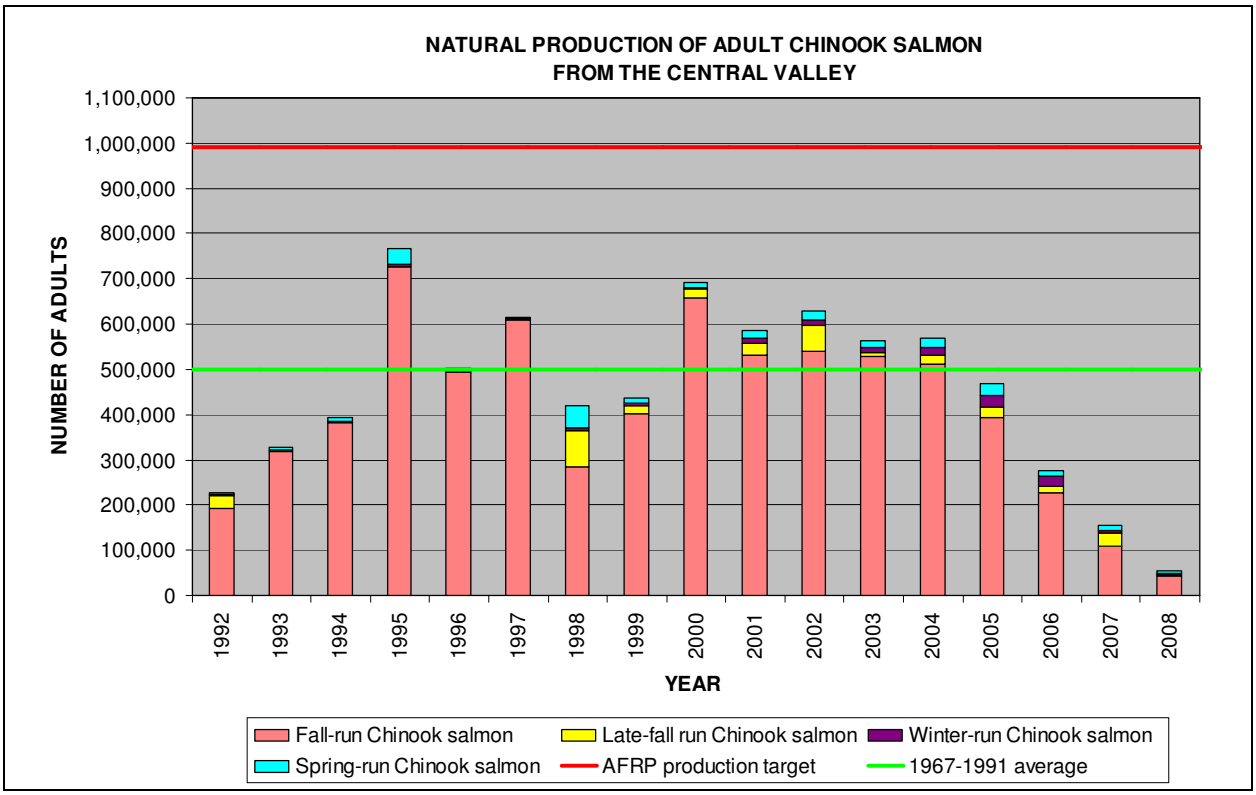


3.1.3 PRODUCTION ESTIMATES FOR THE CENTRAL VALLEY

Estimates of the combined natural production of all four runs of Chinook salmon from the aforementioned 22 watersheds in the Central Valley between 1992 and 2008 are presented in Table 4 and Figure 13. These production estimates only include salmon abundance estimates for watersheds and runs having an AFRP fish production target. For example, the Central Valley-wide production estimates include spring-run Chinook salmon from Butte Creek, Deer Creek, Mill Creek, and the Sacramento River, but do not include spring-run Chinook salmon from other watersheds where spring-run Chinook salmon escapement estimates are available, e.g., Battle Creek, Big Chico Creek, or the Yuba River. The AFRP Central Valley-wide adult Chinook salmon production target is 990,000 salmon. Chinook salmon surveys on the aforementioned 22 watersheds between 1992 and 2008 suggest this production target was never met during that 17-year period.

During the 17-year period between 1992 and 2008, the average contribution of the number of fall-, late-fall-, winter-, and spring-run Chinook salmon to the Central Valley-wide production target was 91%, 4%, 2%, and 3%, respectively.

Figure 13. Estimated total natural production of adult fall-, late-fall-, winter-, and spring-run Chinook salmon from the Central Valley, 1992-2008. Annual estimates reflect the combined total production of all four runs of Chinook salmon from 22 watersheds. The AFRP Central Valley-wide production target for adult Chinook salmon is 990,000 Chinook salmon, and the 1967-1991 baseline average is 497,069 Chinook salmon.



3.2 ADULT SALMON POPULATION ASSESSMENTS

3.2.1. NUMBER OF YEARS WATERSHED-SPECIFIC AFRP PRODUCTION TARGETS WERE MET

Annual monitoring data that quantify natural production of adult Chinook salmon in the Central Valley during the 17-year period between 1992 and 2008 suggest:

- Monitoring data that can be used to estimate salmon production have not been collected during the 1992-2008 post-baseline period in five of the 22 watersheds that have an AFRP fish production target. These watersheds are relatively small and consist of Antelope Creek, Bear River, Big Chico Creek, Calaveras River, and Paynes Creek. Six of the seven "miscellaneous creeks" also have not been surveyed during the post-baseline period.

- Watershed-specific AFRP fall-run Chinook salmon production targets were met six or more times in five of the 21 watersheds with a fall-run target (Figure 14). These

watersheds are: American River, Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River. The remaining 16 watersheds with a fall-run Chinook salmon target have: (a) met their production targets less than three times during the 17-year post-baseline period, or (b) were not surveyed each year since 1991.

- The watershed-specific AFRP production target for late-fall-run Chinook salmon may have been met nine times on Battle Creek (Figure 15). The reason the AFRP's late-fall-run Chinook salmon production target for Battle Creek may (or may not) have been met is described in section 3.1.1.3 of this report. In contrast, the watershed-specific production target for late-fall-run Chinook salmon from the Sacramento River mainstem was met once.

- The watershed-specific AFRP production target for winter-run Chinook salmon was never met on the Sacramento River mainstem (Figure 16). Monitoring data for winter-run Chinook salmon from the Calaveras River have not been collected since 1991; it is therefore not possible to assess if the winter-run Chinook salmon production target for this watershed was met after 1991.

- The watershed-specific AFRP production target for spring-run Chinook salmon was met 14 times on Butte Creek (Figure 17). In contrast, data suggest the watershed-specific production targets for spring-run Chinook salmon were never met on Deer Creek, Mill Creek, and the Sacramento River mainstem.

- The run-specific AFRP production targets for fall, winter-, and spring-run Chinook salmon were never met, and the run-specific AFRP production target for late-fall-run Chinook salmon was met once.

- The Central Valley-wide AFRP production target for the combined total of all four runs of Chinook salmon in 22 watersheds was never met.

Figure 14. Number of times watershed-specific AFRP fall-run Chinook salmon production targets were met or exceeded during the 17-year period 1992-2008. Monitoring data are not available each year in the following watersheds and readers should review Table 1 to understand how frequently monitoring was done for Butte Creek, Cosumnes River, Cottonwood Creek, Cow Creek, Deer Creek, Mill Creek, and seven "miscellaneous creeks". Monitoring data were not collected from Antelope Creek, Bear River, Big Chico Creek, or Paynes Creek between 1992 and 2008.

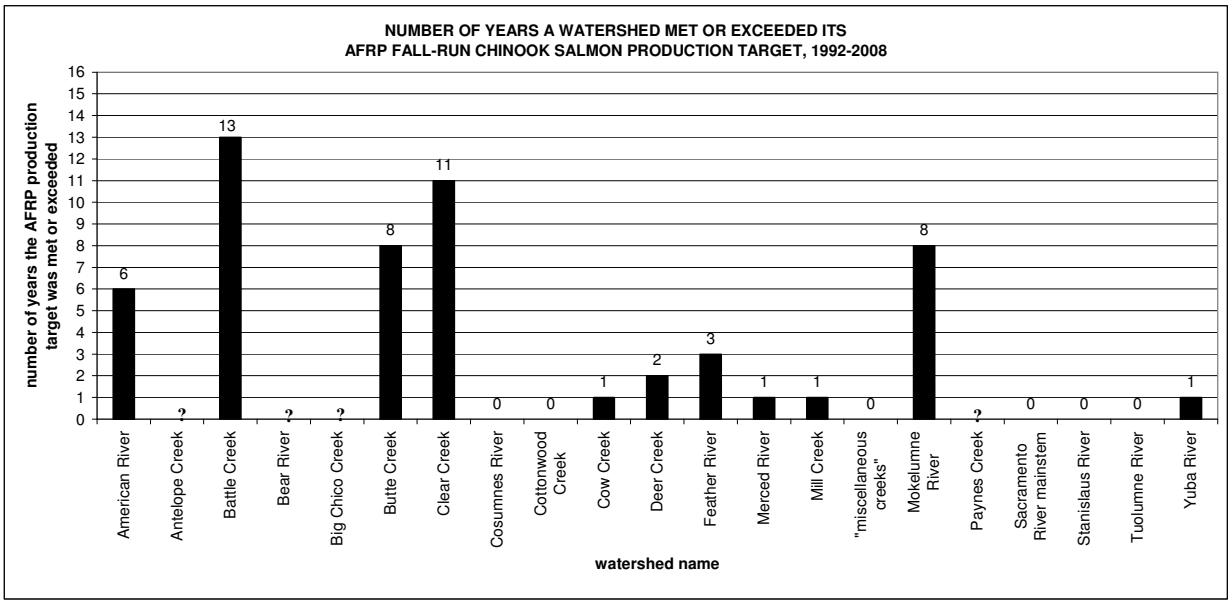


Figure 15. Number of times watershed-specific AFRP late-fall-run Chinook salmon production targets were met or exceeded during the 17-year period 1992-2008. Monitoring data for late-fall-run Chinook salmon from the Sacramento River mainstem are available for 16 of the 17 years since 1991.

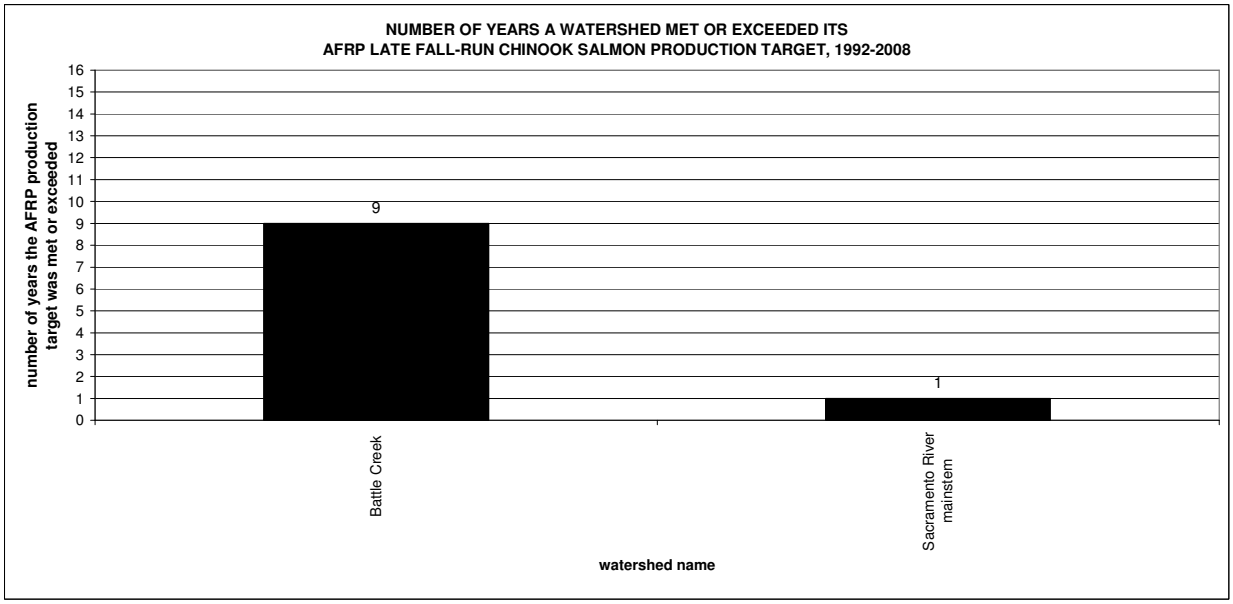


Figure 16. Number of times watershed-specific AFRP winter-run Chinook salmon production targets were met or exceeded during the 17-year period 1992-2008. Monitoring data were not collected from the Calaveras River between 1992 and 2008.

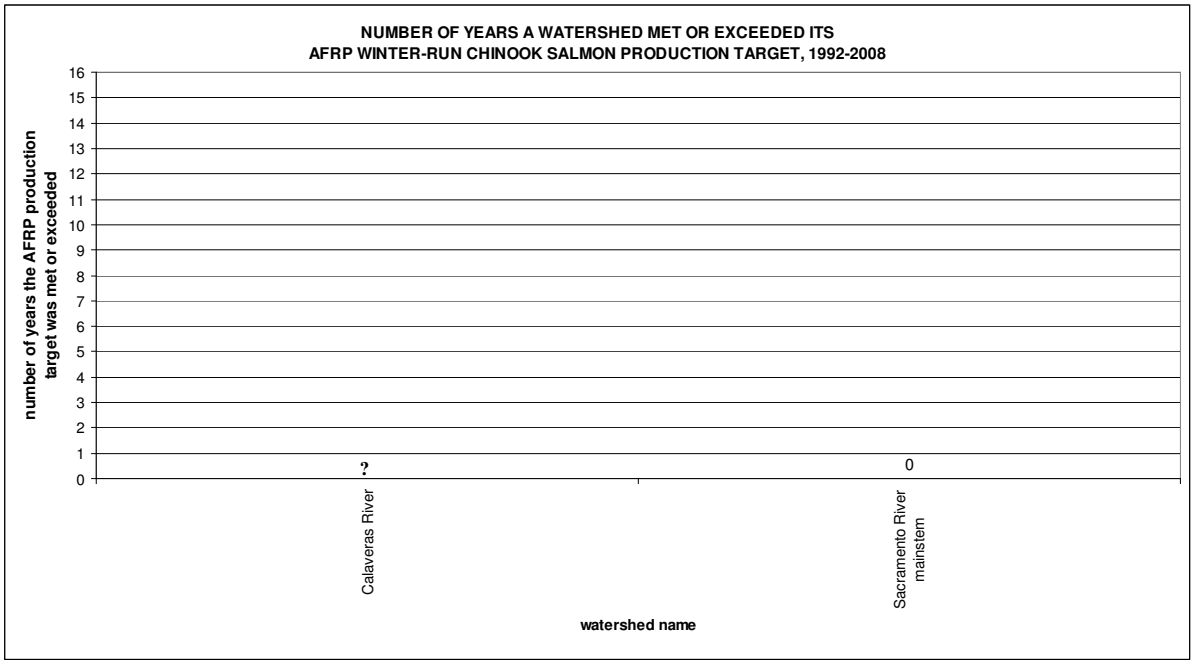
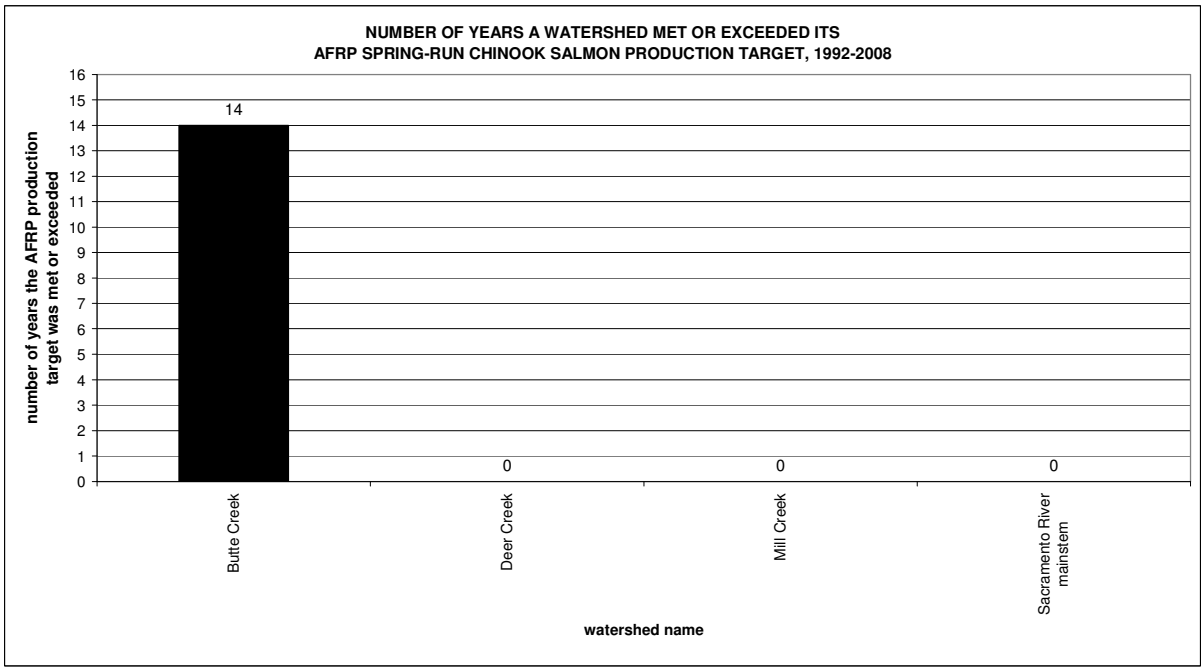


Figure 17. Number of times watershed-specific AFRP spring-run Chinook salmon production targets were met or exceeded during the 17-year period 1992-2008. Monitoring data for spring-run Chinook salmon from the Sacramento River mainstem are currently available for 16 of the 17 years since 1991.



3.2.2 CHANGES IN THE AVERAGE NATURAL PRODUCTION OF CHINOOK SALMON

A comparison of the average natural production of different runs of adult Chinook salmon in 22 watersheds in the Central Valley during the 1967-1991 and 1992-2008 time periods is presented in Table 4, and suggests that watersheds can be characterized as occurring in one of three categories. These include:

Scenario #1: where watersheds experienced an increase in the average natural production over time. Runs and watersheds applicable to this scenario are:

Fall-run Chinook salmon: American River, Battle Creek, Butte Creek, Clear Creek, Cow Creek, Deer Creek, Feather River, Mill Creek, Mokelumne River, and Yuba River.

Late-fall-run Chinook salmon: Battle Creek.

Winter-run Chinook salmon: none

Spring-run Chinook salmon: Butte Creek.

Scenario #2: where watersheds experienced a decrease in the average natural production over time. Runs and watersheds applicable to this scenario are:

Fall-run Chinook salmon: Cosumnes River, Cottonwood Creek, Merced River, miscellaneous creeks, Sacramento River mainstem, Stanislaus River, and Tuolumne River.

Late-fall-run Chinook salmon: Sacramento River mainstem.

Winter-run Chinook salmon: Sacramento River mainstem.

Spring-run Chinook salmon: Deer Creek, Mill Creek, and Sacramento River mainstem.

Scenario #3: where watersheds where insufficient monitoring data were collected to assess a change in the average natural production of a particular run. Runs and watersheds applicable to this scenario are:

Fall-run Chinook salmon: Antelope Creek, Bear River, Big Chico Creek, and Paynes Creek.

Late-fall-run Chinook salmon: none.

Winter-run Chinook salmon: Calaveras River.

Spring-run Chinook salmon: none.

Table 4. Summary statistics of the average natural production of adult fall-, late-fall-, winter, and spring-run Chinook salmon from 22 Central Valley watersheds, 1967-2008. * Indicates a fish hatchery is present in the watershed; presence of hatchery fish can confound estimates of natural production. N = number of years monitoring data were collected during a time period. ** P values <0.05 reflect a statistically significant change with an $\alpha = 0.05$. ??? = insufficient data to assess change in average production or a P value.

Watershed	Run	1967-1991		1992-2008		AFRP fish production target	Percent change in average production 1967-1991 vs. 1992-2008	P-value
		N	Average production	N	Average production			
American River*	Fall-run	25	80,874	17	122,450	160,000	+ 51%	0.056
Antelope Creek	Fall-run	19	361	0	???	720	???	???
Battle Creek*	Fall-run	25	5,013	17	19,800	10,000	+ 295%	.000**
Battle Creek*	Late-fall-run	23	273	17	675	550	+ 147%	.004**
Bear River	Fall-run	1	639	0	???	450	???	???
Big Chico Creek	Fall-run	3	402	0	???	800	???	???
Butte Creek	Fall-run	10	765	12	2,823	1,500	+ 269%	.008**
Butte Creek	Spring-run	25	1,018	17	10,947	2,000	+976%	.000**
Calaveras River	Winter-run	4	770	0	???	2,200	???	???
Clear Creek	Fall-run	16	3,576	17	11,610	7,100	+ 225%	.000**
Cosumnes River	Fall-run	17	1,660	4	374	3,300	- 77%	???
Cottonwood Creek	Fall-run	17	2,964	3	1,888	5,900	- 36%	???
Cow Creek	Fall-run	12	2,330	3	2,708	4,600	+ 16%	???
Deer Creek	Fall-run	23	766	9	1,005	1,500	+ 31%	0.600
Deer Creek	Spring-run	18	3,276	17	2,310	6,500	- 29%	0.974

Table 4 (cont.). Summary statistics of the average natural production of adult fall-, late-fall-, winter, and spring-run Chinook salmon from 22 Central Valley watersheds, 1967-2008. * Indicates a fish hatchery is present in the watershed; presence of hatchery fish can confound estimates of natural production. N = number of years monitoring data were collected during a time period. ** P values <0.05 reflect a statistically significant change with an $\alpha = 0.05$. ??? = insufficient data to assess change in average production or a P value.

Watershed	Run	1967-1991		1992-2008		AFRP fish production target	Percent change in average production 1967-1991 vs. 1992-2008	P-value
		N	Average production	N	Average production			
Feather River*	Fall-run	25	86,028	17	101,595	170,000	+18%	0.214
Merced River*	Fall-run	25	9,005	17	7,583	18,000	- 16%	0.599
Mill Creek	Fall-run	24	2,118	12	2,207	4,200	+ 4%	0.283
Mill Creek	Spring-run	18	2,202	17	1,330	4,400	- 40%	0.262
Miscellaneous Creeks	Fall-run	20	549	2	115	1,100	- 79%	???
Mokelumne River*	Fall-run	25	4,680	17	8,564	9,300	+ 83%	0.010**
Paynes Creek	Fall-run	9	170	0	???	330	???	???
Sacramento River	Fall-run	25	115,369	17	83,249	230,000	- 28%	0.019**
Sacramento River	Late-fall-run	25	33,941	16	20,475	68,000	- 40%	0.017**
Sacramento River*	Winter-run	25	54,316	17	7,789	110,000	- 86%	0.007**
Sacramento River	Spring-run	25	29,412	16	913	59,000	- 97%	0.000**
Stanislaus River	Fall-run	24	10,868	17	6,042	22,000	- 44%	0.525
Tuolumne River	Fall-run	25	18,949	17	7,976	38,000	- 58%	0.044**
Yuba River	Fall-run	25	33,267	17	35,198	66,000	+ 6%	0.497

A comparison of the average natural production of the four runs of Chinook salmon from the Central Valley as a whole during the 1967-1991 and 1992-2008 time periods is presented in Table 5. During the latter period, fall-run Chinook salmon production increased by 9%. In contrast, the production of late-fall-, winter, and spring-run Chinook salmon declined by 42, 86, and 55%, respectively. The natural production of Chinook salmon across the Central Valley during the 1992-2008 time period in the 22 aforementioned Central Valley watersheds was 9% less than during the 1967-1991 baseline period.

Table 5. Summary statistics of the average natural production of four runs of adult Chinook salmon from the Central Valley, 1967-2008.

Chinook salmon group	**1967-1991 average production**	**1992-2008 average production**	**AFRP fish production target**	**Percent change in average production 1967-1991 vs. 1992-2008**
Fall-run	374,064	409,061	750,000	+ 9%
Late-fall-run	34,192	19,946	68,000	- 42%
Winter-run	54,439	7,789	110,000	- 86%
Spring-run	34,374	15,446	68,000	- 55%
Central Valley-wide	497,069	452,243	990,000	- 9%

3.2.3 STATISTICALLY SIGNIFICANT CHANGES IN NATURAL PRODUCTION OF CHINOOK SALMON

An analysis using a nonparametric Mann Whitney U test suggests some watersheds and salmon runs experienced significant changes in average natural production when data from the 1967-1991 and 1992-2008 time periods are compared, i.e., it may be reasonable to reject the null hypothesis in some cases (Table 4). For watersheds containing adult fall-run Chinook salmon, average production appears to be significantly greater from Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River during the 1992-2008 time period than during the 1967-1991 time period. In contrast, significantly fewer adult fall-run Chinook salmon were likely produced on average by the Sacramento River mainstem and Tuolumne River during the post-baseline period. For late-fall-run Chinook salmon, significantly greater numbers of adult salmon appear to have been produced on average from Battle Creek in the post-baseline period, and significantly smaller numbers of adult salmon appear to have been produced from the Sacramento River mainstem. During the post-baseline period, significantly fewer adult winter-run Chinook salmon appear to have been produced on average by the Sacramento River mainstem than during the baseline period. In regard to average natural production of spring-run Chinook salmon, production appears to have been significantly greater in Butte Creek during the post-baseline period, but appears to have been significantly less in the Sacramento River mainstem.

3.3 PRODUCTION OF NON-SALMONID TAXA

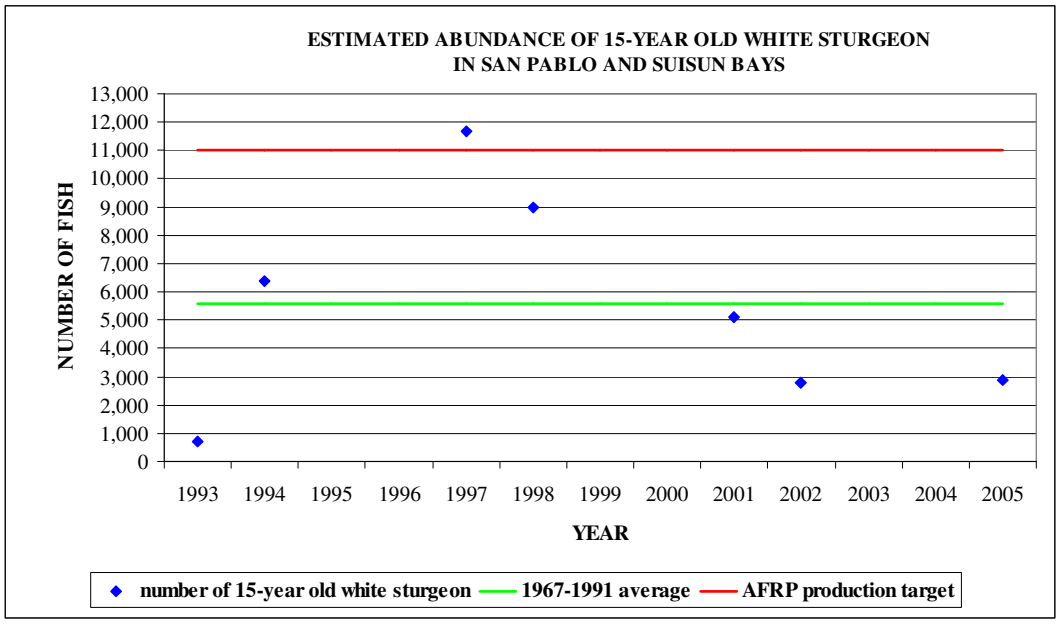
3.3.1 PRODUCTION OF ADULT WHITE AND GREEN STURGEON

Seven censuses were conducted for white sturgeon between 1992 and 2005 (i.e., 1993, 1994, 1997, 1998, 2001, 2002, and 2005). The estimated abundance of 15-year-old white sturgeon in San Pablo and Suisun bays during those seven years ranged between 692 and 11,689 fish (Table 6). The AFRP production target for white sturgeon is 11,000 fish. During the 1992-2005 time period, the estimated number of 15-year-old white sturgeon in San Pablo and Suisun bays exceeded the AFRP production target in one of the seven years when sampling was done (Figure 18).

Table 6. Estimated abundance of white sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

Year	Estimated abundance of white sturgeon ≥ 40 inches in total length	Percentage of 15-year-old white sturgeon in the population ≥ 40 inches in total length	Estimated abundance of 15-year-old white sturgeon
1993	18,257	3.789	692
1994	144,672	4.418	6,392
1997	143,795	8.129	11,689
1998	98,717	9.088	8,971
2001	57,641	8.898	5,129
2002	32,283	8.595	2,775
2005	55,180	5.252	2,898

Figure 18. Estimated abundance of 15-year old white sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

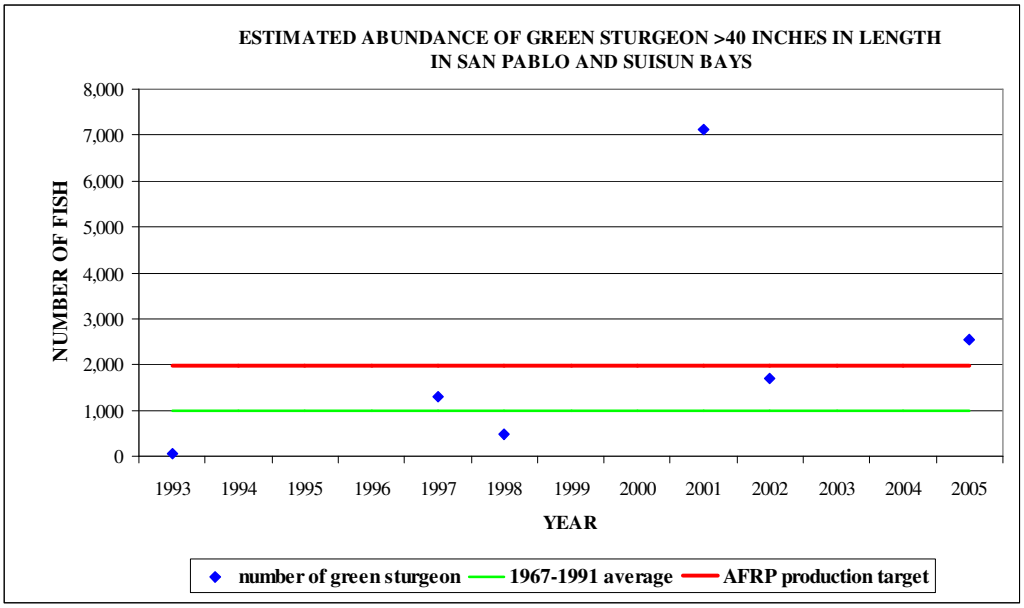


Six of the seven white sturgeon censuses can be used to develop abundance estimates for green sturgeon that were ≥ 40 inches in length in San Pablo and Suisun bays. These were conducted in 1993, 1997, 1998, 2001, 2002, and 2005. Because the CDFG did not capture green sturgeon during the sturgeon census in 1994, it is not possible to develop an abundance estimate for green sturgeon in the two bays that year. The estimated abundance of green sturgeon ≥ 40 inches in length in the two bays between 1993 and 2005 ranged between 68 and 7,117 fish (Table 7). The AFRP production target for green sturgeon is 2,000 fish. During the 1992-2005 time period, the estimated abundance of green sturgeon ≥ 40 inches in length in San Pablo and Suisun bays exceeded the AFRP production target in two of the six years when abundance estimates could be calculated (Figure 19).

Table 7. Estimated abundance of green sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.

Year	Estimated abundance of white sturgeon ≥ 40 inches in total length	Number of captured white sturgeon ≥ 40 inches in total length	Number of captured green sturgeon ≥ 40 inches in total length	Ratio of white to green sturgeon	Estimated abundance of green sturgeon ≥ 40 inches in total length
1993	18,257	534	2	267.0:1	68
1994	144,672	593	0	---	---
1997	143,795	1,321	12	110.1:1	1,306
1998	98,717	1,469	7	209.9:1	470
2001	57,641	1,080	133	8.1:1	7,117
2002	32,283	478	25	19.1:1	1,690
2005	55,180	259	12	21.6:1	2,555

Figure 19. Estimated abundance of adult green sturgeon in San Pablo Bay and Suisun Bay, 1993-2005.



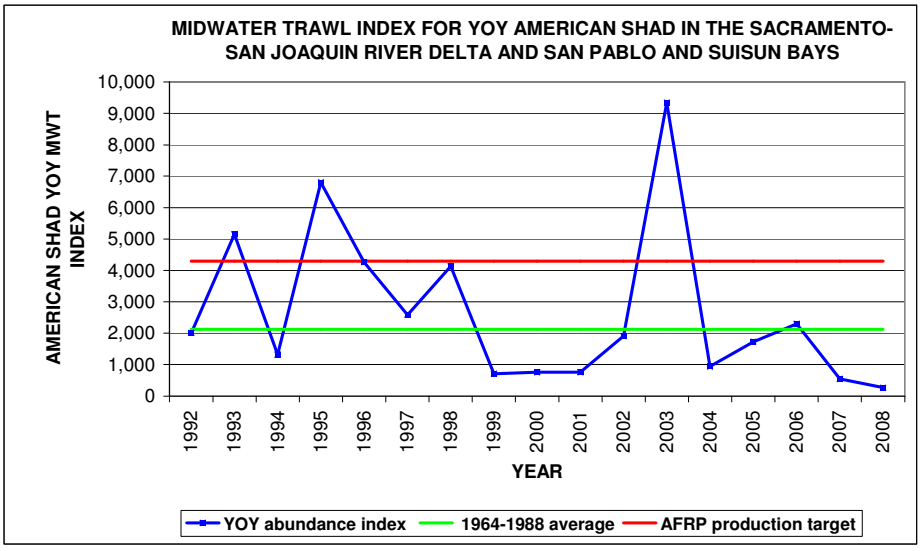
3.3.2 PRODUCTION OF JUVENILE AMERICAN SHAD

The midwater trawl index for YOY American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays during the 1992-2008 time period ranged between 271 and 9,342 (Table 8). The AFRP production target for American shad is 4,300 fish. Between 1992 and 2008, the MWT YOY index exceeded the AFRP production target in 3 of 17 years (Figure 20).

Table 8: Midwater trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays, 1992-2008.

Year	MWT index for young-of-the-year American Shad
1992	2,006
1993	5,153
1994	1,319
1995	6,803
1996	4,260
1997	2,591
1998	4,134
1999	715
2000	764
2001	761
2002	1,913
2003	9,342
2004	947
2005	1,735
2006	2,303
2007	551
2008	271

Figure 20. Midwater trawl index for young-of-the-year American shad in the Sacramento-San Joaquin River Delta and San Pablo and Suisun bays, 1992-2008.



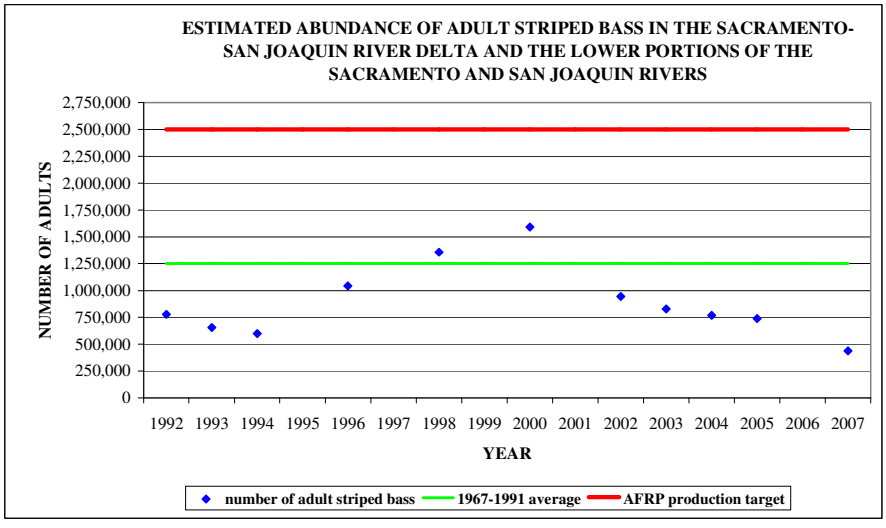
3.3.3 PRODUCTION OF ADULT STRIPED BASS

CDFG did not conduct surveys for adult striped bass in 1995, 1997, 1999, and 2001. The abundance of adult striped bass in 2006 was not determined because striped bass were not tagged that year. The 2004, 2005, and 2007 abundance estimates provided below only include male fish because very few females were tagged those years. Between 1992 and 2007, abundance of adult striped bass in the Sacramento-San Joaquin River Delta, the portion of the Sacramento River downstream of Colusa, and the portion of the San Joaquin River downstream from Mossdale ranged between 436,688 and 1,591,419 fish (Table 9). Abundance estimates for 2004, 2005, and 2007 are provisional. The AFRP production target for striped bass is 2,500,000 fish. Between 1992 and 2007, the AFRP striped bass production target was not met during the 11 years when population estimates were developed (Figure 21).

Table 9: Estimated abundance of adult striped bass in the Sacramento-San Joaquin River Delta, Sacramento River downstream from the town of Colusa, and San Joaquin River downstream from the town of Mossdale, 1992-2007. * = estimate only includes male fish.

Year	Estimated number of adult striped bass
1992	777,293
1993	656,506
1994	599,770
1996	1,043,239
1998	1,356,412
2000	1,591,419
2002	945,878
2003	829,111
2004*	767,312
2005*	738,740
2007*	436,688

Figure 21. Estimated abundance of adult striped bass in the Sacramento-San Joaquin River Delta, Sacramento River downstream from the town of Colusa, and San Joaquin River downstream from the town of Mossdale, 1992-2007. * = estimate only includes male fish.



SECTION 4: DISCUSSION

The "Discussion" section of this document provides an assessment of the overall (cumulative) effectiveness of habitat restoration actions implemented pursuant to Section 3406(b) of the CVPIA in meeting the AFRP production targets for eight anadromous fish taxa. These habitat restoration actions include water management modifications, structural modifications, habitat restoration, and fish screens.

As stated in the "Data Caveats" section of this report, several inherent challenges or assumptions are associated with monitoring anadromous fish species in the Central Valley. These issues must be acknowledged as temporal changes in the production of anadromous fish are assessed. For example, monitoring activities for the eight taxa in a given location may not have been conducted with a standardized protocol and with the same level of effort over time. Developing definitive conclusions as to how fish production or abundance has changed over time is therefore difficult.

To the extent possible, this report attempts to synthesize data for the 1969-1991 and 1992-2008 time periods using the same analytical techniques and approaches. This effort should increase comparability of data collected during the two time periods and thereby increase the probability of making accurate inferences about changes in fish numbers. This report also provides the most current data available at the time of report production, i.e., the individuals that were responsible for collecting different data sets (e.g., for green and white sturgeon, striped bass, and American shad) were contacted a few weeks prior to the development of this report to ensure that the most accurate, timely data were used to quantify fish abundance and population estimates.

4.1 PROGRESS TOWARD AFRP PRODUCTION TARGETS FOR CHINOOK SALMON

The production of Chinook salmon at fish hatcheries in the Central Valley makes it difficult to accurately monitor the natural production of Chinook salmon. These facilities are located on the American River, Battle Creek, Feather River, Merced River, Mokelumne River, and Sacramento River mainstem. These hatcheries, with the exception of the Livingston Stone National Fish Hatchery on the Sacramento River mainstem, produced large numbers of unmarked juvenile fall-run Chinook salmon for many years or decades prior to 2007. If hatchery-produced juvenile salmon are not marked prior to their release from a hatchery, it is difficult to identify these salmon when they return to a river to spawn as adults. This factor makes it difficult to accurately quantify the relative proportion of natural- vs. hatchery-origin Chinook salmon in a watershed.

The calculations in the Chinookprod spreadsheet currently rely on "best professional judgments" in regard to the amount of in-river angler harvest and the estimated hatchery proportion in each watershed. The accuracy of the natural production estimates has been the subject of some debate, particularly in regard to the estimated hatchery proportions. An effort to lay the groundwork to accurately quantify the relative proportion of natural- vs. hatchery-origin fall-run Chinook salmon has occurred since 2007; this effort involves the marking and coded wire

tagging of 25% of the fall-run Chinook salmon produced at fish hatcheries in the Central Valley. In 2009, many of the brood year 2006 juvenile fall-run Chinook salmon that were marked in 2007 will return to the Central Valley to spawn as 3-year-old adult fish. The collection and analysis of these coded wire tagged salmon is expected to provide an enhanced ability to quantify the hatchery proportion in different Central Valley rivers and streams, and more accurate production estimates using these hatchery proportions will be provided by the CAMP as these hatchery proportions become available.

A review of information in the introduction section of this document is as follows:

- The CVPIA baseline period encompasses a 25-year period between 1967 and 1991, and a 17-year post-baseline period between 1992 and 2008;

- There are 29 combinations (i.e., permutations) of watersheds and runs of Chinook salmon with an AFRP production target;

- Twenty-two watersheds have one or more AFRP fish production targets; and

- Twenty-one watersheds have a fall-run Chinook salmon production target, two watersheds have a late-fall-run Chinook salmon production target, two watersheds have a winter-run Chinook salmon production target, and four watersheds have a spring-run Chinook salmon production target.

An overall assessment of changes in natural production of different runs of Chinook salmon in the 22 watersheds with an AFRP production target is summarized in Table 1 on page 2. The data in that table indicates that since 1991:

1. Monitoring data have not been collected during the 1992-2008 post-baseline period in five of the 22 watersheds that have an AFRP fish production target. These watersheds are relatively small and consist of Antelope Creek, Bear River, Big Chico Creek, Calaveras River, and Paynes Creek.

2. The watershed-specific AFRP fall-run Chinook salmon production targets were met six or more times in five of the 21 watersheds with a fall-run Chinook salmon target. These watersheds are: American River, Battle Creek, Butte Creek, Clear Creek, and the Mokelumne River. The remaining 16 watersheds have: (a) met their productions targets less than three times over the 17-year post-baseline period, or (b) were not surveyed each year since 1991.

3. The watershed-specific AFRP late-fall-run Chinook salmon production target for Battle Creek was met nine times in the post-baseline period, and the Sacramento River mainstem never met its AFRP late-fall-run Chinook salmon target in the 16 years when monitoring data were collected.

4. The watershed-specific AFRP winter-run Chinook salmon production target for the Sacramento River mainstem has never been met in the post-baseline period, and

monitoring data have not been collected from the Calaveras River to assess progress toward its AFRP winter-run Chinook salmon target.

5. The watershed-specific AFRP spring-run Chinook salmon production target was met 14 times on Butte Creek in the post-baseline period. The other three watersheds with a spring-run Chinook salmon target (Deer Creek, Mill Creek, and the Sacramento River mainstem) have never met their AFRP targets in the post-baseline period.

6. Six combinations of watersheds and runs have significantly greater number of Chinook salmon in the post-baseline period than the 1967-1991 baseline period. In contrast, five combinations of watersheds and runs have significantly fewer numbers of Chinook salmon. In nine combinations of watersheds and runs, there were no significant changes over time, and there were nine combinations where insufficient monitoring data were collected to determine if there was a change.

Other data presented in this report demonstrate the:

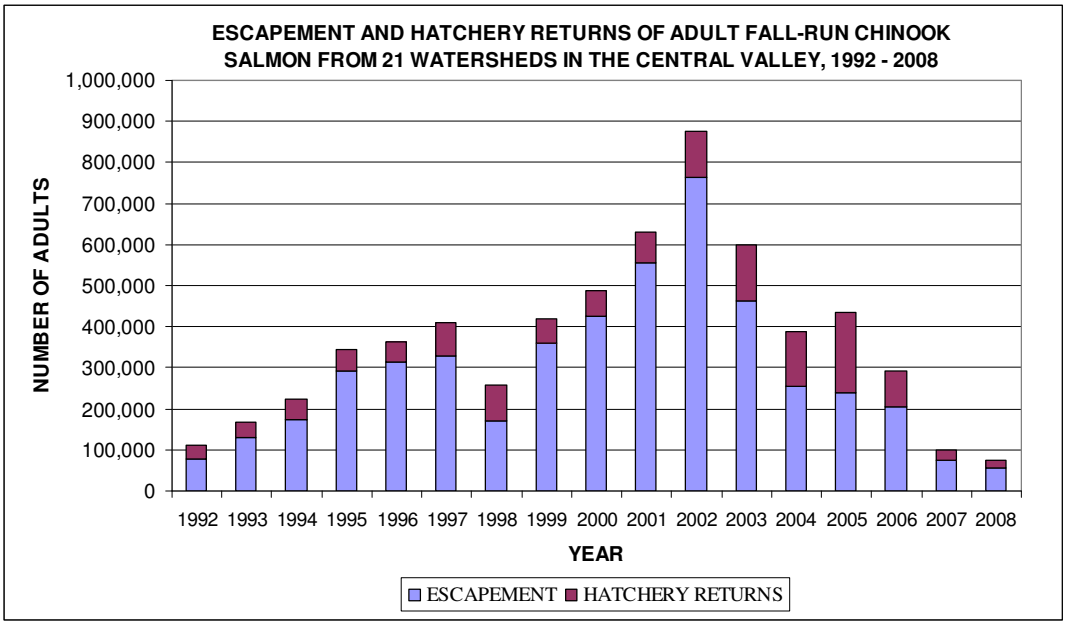
7. Run-specific AFRP production targets for fall-, winter-, and spring-run Chinook salmon were never met in the post-baseline period, and the run-specific AFRP production target for late-fall-run Chinook salmon was met once.

8. Central Valley-wide AFRP production target for the combined total of all four runs of Chinook salmon was never met in the post-baseline period.

In 2008 relative to 2007, the production of Chinook salmon declined in 20 of the 22 permutations of runs and watersheds where Chinook salmon were monitored. The only runs and watersheds where production was greater in 2008 than 2007 were fall-run Chinook salmon from the Tuolumne and Stanislaus rivers. The decline in salmon production in 2008 affected Chinook salmon from watersheds that historically have been viewed as success stories in the context of CVPIA and CALFED restoration activities. For example, the production of fall-run Chinook salmon from Clear Creek in 2007 and 2008 was less than the watershed's AFRP fish production target, despite the fact that the watershed exceeded its production target for eight consecutive years prior to 2007.

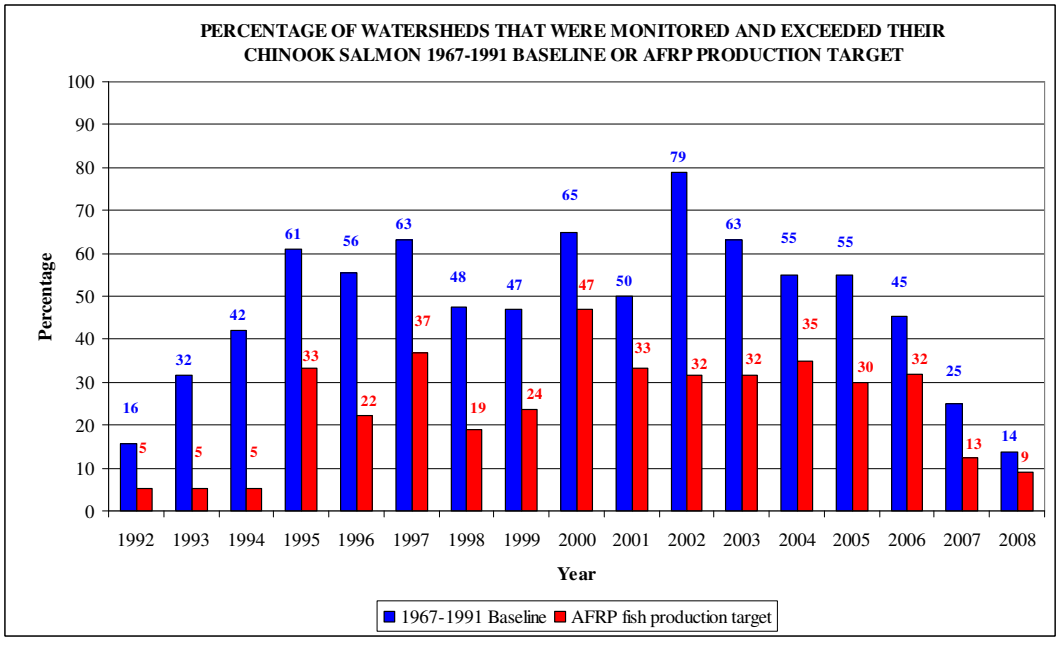
Part of the decline in Chinook salmon production in 2008 can be attributed to the fact that approximately one half of a watershed's annual production in the Chinookprod spreadsheet is normally attributed to salmon that are harvested in the Pacific Ocean and restrictions prohibiting the ocean harvest of Chinook salmon were in effect in 2008. However, when in-river escapement and hatchery returns are compared across years with and without ocean harvest restrictions, it becomes obvious the 2008 in-river returns were substantially lower than levels during the 1992-2007 time period. For example, the 2008 combined annual in-river escapement and hatchery returns for the 21 watersheds possessing a fall-run Chinook salmon production target was less than any other year since 1991 (Figure 22). This decline occurred despite the total ban on ocean harvest and a substantial ban on in-river angler harvest which should have resulted in substantial numbers of the unharvested fish returning to Central Valley rivers and streams to spawn.

Figure 22. Combined annual in-river escapement and hatchery returns for the 21 watersheds possessing an AFRP fall-run Chinook salmon production target, 1992-2008.



Progress in achieving the Chinook salmon production targets called for in the CVPIA has been less successful since 2000. In that year, 47% of the watersheds that were monitored exceeded their AFRP production target (Figure 23). By 2008, only 9% of the monitored watersheds exceeded their AFRP target. The recent decline in Chinook salmon production has become so substantial that only 14% of the watersheds monitored in 2008 exceeded the production levels observed during the 1967-1991 baseline period.

Figure 23. Percentage of watersheds that were monitored and exceeded their Chinook salmon 1967-1991 baseline or AFRP production target.



4.2 PROGRESS TOWARD AFRP PRODUCTION TARGETS FOR NON-SALMONID SPECIES

A discussion describing changes in the production of white sturgeon and green sturgeon during the 1992-2005 time period is provided in the 2008 CAMP annual report (USFWS 2008). Because new data from 2006 and beyond are not currently available for these species, this 2009 CAMP annual report will not re-assess progress toward those species' AFRP production targets.

The 2008 midwater trawl index for juvenile American shad was the lowest on record since monitoring for the species began in 1967, and is well below the species' AFRP production target. The process of collecting data to calculate the MWT index did vary prior to 1980; i.e., during a portion of the period of record that was used to develop the AFRP production. Overall, however, the vast majority of the core sampling stations used to calculate the MWT index have been monitored on a consistent basis since 1980 (Dave Contreras, CDFG, pers. comm.). The depressed MWT index for juvenile American shad is therefore likely to reflect an actual decline in fish numbers and probably is not an artifact of reduced sampling effort. The conclusion is further substantiated because the geographic distribution of the area sampled during the MWT index has remained essentially unchanged since 1980.

Surveys used to estimate the abundance of striped bass also suggest this species' abundance is at unusually low levels. The 2007 striped bass abundance estimate, for example, is the smallest estimate during the 1992-2008 time period; this number is likely to be revised, however, as additional bass surveys are conducted and female adult bass are incorporated into the revised 2007 estimate. There is little reason to believe, however, that revised 2004, 2005, and 2007 striped bass abundance estimates that include female fish will make it more likely this species' AFRP production target was met because the female contribution is likely to be relatively small compared to male fish.

4.3 ADDENDUM TO THE 2008 CAMP ANNUAL REPORT AND A DISCUSSION OF STATISTICAL ANALYSES USED IN THE 2008 AND 2009 REPORTS

Different statistical tests may be used to identify statistically significant changes in the average values of two samples or populations. In the 2008 CAMP annual report (USFWS 2008), a Student's t test was used to identify watersheds and salmon runs where the average natural production was greater in the 1992-2008 post-baseline period relative to the 1967-1991 baseline period. One of the underlying assumptions associated with the use of the Student's t test requires that data be normally distributed. Prior to the use of the Student's t test referenced in the 2008 CAMP annual report, an analysis was <u>not</u> conducted to determine if the natural production values for different runs and watersheds and the baseline and post-baseline periods were normally distributed. As the 2009 CAMP annual report was being prepared, the production data were superficially explored and that analysis suggests production values for at least some watersheds may not be normally distributed, i.e., at least one assumption associated with the Student's t test may not have been met. Therefore, the inferences made in the 2008 CAMP

annual report which suggest that significant temporal changes in salmon production in some watersheds occurred may be spurious.

The use of the nonparametric Mann Whitney U test does not require that data be normally distributed. As such, the Mann Whitney U test is more flexible than the Student's t test, but it is also less powerful, i.e., a greater change is required before the nonparametric test is able to detect a significant change. The assumptions associated with the Mann Whitney U test are as follows: assumption #1, there are two independent samples that are randomly selected; assumption #2, each of the two samples has more than 10 values; and assumption #3, there is no requirement that the two populations have a normal distribution of any other particular distribution.

Assumptions #2 and #3 can readily be met in the context of testing whether there are significant differences in the average natural production of Chinook salmon from different watersheds between the baseline and post-baseline periods. Assumption 1 possesses two aspects: (a) there are two independent samples, and (b) the samples are randomly chosen. To varying degrees each year, the salmon that return to spawn in a particular watershed are not independent because the same brood cohort contributes to salmon production over a period of two to five years as adult fish return to spawn. That lack of independence may, however, be relatively weak compared to sampling noise. In regard to samples being randomly chosen, at least some of the data used to develop watershed-specific Chinook salmon production estimates is based on random samples, and some is not. For example, the CDFG's Ocean Salmon Project which collects commercial and recreational harvest data pertaining to Chinook salmon in the Pacific Ocean does collect recreational salmon harvest data in a randomized manner.

Despite the difficulty in meeting the assumptions associated with different statistical tests, circumstantial data does suggest that significant differences in the average Chinook salmon production in some watersheds have occurred over time. For example, the parametric Student's test referenced in the 2008 CAMP annual report identified 14 combinations of salmon runs and watersheds where average production was significantly greater or less in the post-baseline period than the baseline period. The nonparametric Mann Whitney U test referenced in this report indicates that 11 combinations of salmon runs and watersheds have an average production that is significantly greater or less in the post-baseline period than the baseline period. All the changes in abundance (either negative or positive) are consistent using both tests, i.e., there was not a situation where one test indicated a decrease, while another test indicated an increase in salmon abundance over time. Also, two of the three combinations of watersheds and runs that were found to have a significant difference using the Student's t test and data through 2007, i.e., spring-run Chinook salmon from Mill Creek and fall-run Chinook salmon from the Stanislaus River, also have a significant difference using the Mann Whitney U test and data through 2007.

4.4 RESTRICTIONS THAT LIMIT THE HARVEST OF CHINOOK SALMON IN 2009

The 2008 CAMP annual report describes the process by which the 2008 ocean harvest and in-river angler harvest of fall-run Chinook salmon from the Central Valley was substantially curtailed. In 2009, restrictions were again put into effect that limited the commercial and/or

recreational harvest of fall-run Chinook salmon from the Central Valley. The process that resulted in limits to the 2009 salmon harvest is as follows:

1. The Pacific Fisheries Management Council (PFMC) has developed a Pacific Coast Salmon Plan quantifying conservation targets for different zones where salmon harvest activities occur. The conservation targets reflect the minimum number of Chinook salmon that should be produced in different management areas to ensure that salmon harvest practices occur in a sustainable manner. If fisheries data suggest the conservation target for a particular management area is not likely to be met, the plan requires the closure of harvest activities in that area. On April 8, 2009, the PFMC developed a recommendation to preclude recreational and commercial ocean harvest of Chinook salmon between Cape Falcon, Oregon and the United States-Mexico border because data suggested the fall-run Chinook salmon conservation objective for that area could not be met. The recommendation pertained to the period between May 26, 2009, and August 28, 2009. On May 5, 2009, the National Marine Fishery Service published a regulation in the Federal Register (74 FR 20610) that adopted the PFMC recommendation to eliminate recreational and commercial ocean harvest of Chinook salmon in federal waters (3 to 200 nautical miles offshore) south of Cape Falcon, Oregon.

2. The California Fish and Game Commission (Commission) determines the amount of ocean harvest of fisheries that occur in California state waters (0 to 3 nautical miles offshore from the California coastline). On April 21, 2009, the Commission adopted the abovementioned PFMC recommendation, and voted to prohibit recreational and commercial ocean harvest of Chinook salmon in California state waters.

3. On April 21, 2009, the Commission also voted to eliminate the in-river and downstream angler harvest of Chinook salmon in inland waters of the Central Valley with one exception. The Sacramento River mainstem between the Red Bluff Diversion Dam and Knights Landing was open to salmon fishing from November 16 to December 31, 2009 with a one salmon bag limit. All other Central Valley rivers and streams where Chinook salmon were historically harvested (e.g., the American and Feather Rivers), were closed to angler harvest in 2009.

4.5 POSSIBLE REASONS FOR THE RECENT, MARKED DECLINES IN PRODUCTION OF FALL-RUN CHINOOK SALMON

The causal factors for the recent, marked decline in the abundance of fall-run Chinook salmon from the Central Valley have been the subject of substantial debate and analysis. To some degree, it is reasonable to assume the recent decline is an extension and exacerbation of anthropogenic factors adversely affecting all four runs of Chinook salmon from the Central Valley since the late 1800s. The historical and current factors affecting the runs have been described by several authors (e.g., Yoshiyama et al. 1998; Moyle 2002; NMFS 2009). These factors (in no particular order) include, but are not limited to:

1. The construction of dams and water diversion infrastructure which have eliminated historical salmon spawning areas or altered hydrologic conditions;
2. Harvest of adult salmon in the ocean and natal watersheds;
3. Entrainment of juvenile salmon by water diversion infrastructure;
4. Loss of juvenile salmon floodplain and estuarine rearing habitat through diking and draining of habitat;
5. Enhanced predation of juvenile salmon, particularly by non-native fish species;
6. A variety of effects relating to the hatchery production of juvenile salmon (e.g., changes in the genetic diversity of a native salmon stock due to introgression with hatchery-produced salmon);
7. Elevated incidents of diseases that may affect adult and juvenile salmon;
8. Pollution;
9. Losses of riparian cover that lead to elevated temperature regimes in the areas where adult and juvenile salmon could occur;
10. Siltation of spawning areas where juvenile salmon hatch or rear;
11. Introduced species that change the processes and function in the ecosystem where salmon occur; and
12. Factors that include long periods of drought, extreme flood events, and periods of low ocean productivity.

In a comprehensive review, Lindley et al. (2009) identified specific factors that were probably responsible for the large decline in the number of adult fall-run Chinook salmon that returned to the Central Valley in 2007. The proximate cause for the decline probably consisted of anomalous conditions in the coastal portion of the Pacific Ocean in 2005 and 2006 which then resulted in unusually poor survival of the 2004 and 2005 broods of juvenile fall-run Chinook salmon that had migrated to the ocean. Some of the anomalous conditions in the ocean that may have caused the demise of juvenile Chinook salmon entering the Pacific Ocean include weak upwelling of ocean water which resulted in low primary productivity, warm sea surface temperatures that may have led to a general reduction in fish health, and low densities of the prey items that juvenile salmon consume. Lindley et al. (2009) also suggest other factors likely compounded the problems created by unusual ocean conditions. These include, in descending order of importance:

1. The ongoing degradation of freshwater and estuarine habitats that juvenile salmon depend upon for rearing and growth;

2. The production of juvenile fall-run Chinook salmon at four fish hatcheries in the Central Valley which have contributed to the loss of genetic diversity in, and therefore the fitness of, native salmon populations; and

3. Inaccurate forecasts of the number of adult salmon that were projected to return to the Central Valley to spawn, and the subsequent establishment of harvest levels that over-estimated the number of adult salmon that could be harvested on a sustainable basis.

Some of the factors responsible for reductions in Chinook salmon populations can be minimized through restoration actions pursuant to the CVPIA. For example, adverse effects related to

changes in the quality of gravel substrates where salmon eggs are laid, hydrologic conditions, entrainment of juvenile salmon, and the loss of juvenile salmon rearing habitat can be minimized by management actions conducted by the Spawning Gravel Program, Dedicated Project Yield Program, Anadromous Fish Screen Program, and Anadromous Fish Restoration Program, respectively. It is not clear, however, if the cumulative benefits created by these restoration programs and other programs administered by entities such as the CDFG or National Marine Fisheries Service can successfully offset conditions in ocean conditions where salmon spend approximately two-thirds of their lives.

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APPENDIX A: RAW DATA USED TO ESTIMATE PRODUCTION OF ADULT CHINOOK SALMON

Ocean harvest estimates of Chinook salmon

Year	Commercial harvest for San Francisco	Recreational harvest for San Francisco	Commercial harvest for Monterey	Recreational harvest for Monterey	Total ocean harvest attributable to the Central Valley
1992	95,800	47,193	64,500	19,526	227,019
1993	154,999	78,733	104,663	20,584	358,979
1994	219,856	140,977	705,508	24,835	456,176
1995	357,486	155,677	313,112	198,875	1,025,150
1996	167,379	84,471	181,467	44,812	478,129
1997	253,484	123,974	228,731	84,427	690,616
1998	126,120	70,969	95,433	43,468	335,990
1999	180,960	69,251	78,709	7,140	336,060
2000	250,368	64,653	197,184	81,782	593,987
2001	136,630	39,856	35,940	20,039	232,465
2002	242,872	87,008	69,980	47,703	447,563
2003	202,876	56,616	36,099	13,126	308,717
2004	298,229	130,220	64,707	44,845	538,001
2005	170,531	72,824	117,408	30,706	391,469
2006	47,689	54,926	11,204	10,970	124,789
2007	75,254	16,796	14,009	6,261	112,320
2008	0	0	0	0	0

Total Ocean Harvest Values include the number of fish that were captured for commercial and recreation purposes from San Francisco and Monterey. The fish that are caught from boats that originate in the ports are thought to originate in the Central Valley. The source of the data is the *Review of 2008 Ocean Salmon Fisheries* (PFMC 2009); commercial harvest data is provided in Table A-3 and recreational harvest data is provided in Table A-5.

1992 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	4,811	6,456	5,070	25,560	41,897	60	25,138
Antelope Creek						80	
Battle Creek	5,433	7,275	1,271	21,879	35,858	10	3,586
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	600	0	60	1,037	1,697	80	1,358
Cosumnes River						100	
Cottonwood Creek	1,585	0	159	2,725	4,468	80	3,575
Cow Creek						80	
Deer Creek						80	
Feather River	24,105	17,937	8,408	78,937	129,387	60	77,632
Merced River	618	368	49	1,627	2,662	90	2,396
Mill Creek	999	0	100	1,728	2,827	80	2,262
"miscellaneous creeks"						80	
Mokelumne River	935	710	165	2,826	4,636	60	2,782
Paynes Creek						80	
Sacramento River mainstem	32,229	0	3,223	55,471	90,923	60	54,554
Stanislaus River	255	0	13	427	695	100	695
Tuolumne River	132	0	7	224	362	100	362
Yuba River	6,362	0	636	10,940	17,938	100	17,938
Total	78,064	32,746	19,160	203,382	333,352		192,277
Late-Fall Run Chinook Salmon							
Battle Creek	0	344	69	647	1,060	10	106
Sacramento River mainstem	9,787	0	1,957	18,377	30,122	91.8	27,652
Total	9,787	344	2,026	19,024	31,181		27,758
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,203	34	0	1,930	3,167	100	3,167
Calaveras River							
Total	1,203	34	0	1,930	3,167	100	3,167
Spring-Run Chinook Salmon							
Butte Creek	730	0	73	1,258	2,061	100	2,061
Deer Creek	209	0	21	360	590	100	590
Mill Creek	237	0	24	408	669	100	669
Sacramento River mainstem	371	0	74	697	1,143	100	1,143
Total	1,547	0	192	2,724	4,463		4,463
Total 1992 Natural Production of Adult Chinook Salmon							**227,664**

NE = No Estimate

1993 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	28,754	10,656	17,735	99,375	156,520	60	93,912
Antelope Creek						80	
Battle Creek	11,029	7,587	1,862	35,620	56,097	10	5,610
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	1,246	0	125	2,401	3,771	80	3,017
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	72	0	7	141	220	80	176
Feather River	30,923	16,663	9,517	99,305	156,408	60	93,845
Merced River	1,269	409	84	3,071	4,833	90	4,350
Mill Creek	1,975	0	198	3,777	5,950	80	4,760
"miscellaneous creeks"						80	
Mokelumne River	993	2,164	316	6,037	9,509	60	5,706
Paynes Creek						80	
Sacramento River mainstem	46,231	0	4,623	88,431	139,286	60	83,571
Stanislaus River	677	0	34	1,236	1,946	100	1,946
Tuolumne River	471	0	24	847	1,342	100	1,342
Yuba River	6,703	0	670	12,815	20,188	100	20,188
Total	130,343	37,479	35,193	353,055	556,070		318,422
Late-Fall Run Chinook Salmon							
Battle Creek	0	528	106	1,107	1,741	10	174
Sacramento River mainstem	739	0	148	1,550	2,436	91.8	2,237
Total	739	528	253	2,656	4,177		2,411
Winter-Run Chinook Salmon							
Sacramento River mainstem	378	0	0	646	1,024	100	1,024
Calaveras River							
Total	378	0	0	646	1,024	100	1,024
Spring-Run Chinook Salmon							
Butte Creek	650	0	65	1,236	1,951	100	1,951
Deer Creek	259	0	26	493	778	100	778
Mill Creek	61	0	6	116	183	100	183
Sacramento River mainstem	391	0	78	811	1,280	100	1,280
Total	1,361	0	175	2,656	4,193		4,193
Total 1993 Natural Production of Adult Chinook Salmon							**326,050**

NE = No Estimate

1994 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	31,520	8,567	18,039	98,903	157,029	60	94,218
Antelope Creek						80	
Battle Creek	24,274	18,991	4,327	80,982	128,573	10	12,857
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	2,546	0	255	4,761	7,562	80	6,049
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	307	0	31	584	922	80	737
Feather River	38,382	18,843	11,445	116,869	185,539	60	111,323
Merced River	2,646	943	179	6,423	10,191	90	9,172
Mill Creek	1,081	0	108	2,021	3,210	80	2,568
"miscellaneous creeks"						80	
Mokelumne River	1,238	1,919	316	5,929	9,401	60	5,641
Paynes Creek						80	
Sacramento River mainstem	58,546	0	5,855	109,593	173,993	60	104,396
Stanislaus River	1,031	0	52	1,842	2,924	100	2,924
Tuolumne River	506	50	25	898	1,430	100	1,430
Yuba River	10,890	0	1,089	20,391	32,370	100	32,370
Total	172,967	49,313	41,720	449,196	713,145		383,686
Late-Fall Run Chinook Salmon							
Battle Creek	0	598	120	1,227	1,945	10	195
Sacramento River mainstem	291	0	58	597	946	91.8	869
Total	291	598	178	1,825	2,892		1,063
Winter-Run Chinook Salmon							
Sacramento River mainstem	144	42	0	319	506	100	506
Calaveras River							
Total	144	42	0	319	506	100	506
Spring-Run Chinook Salmon							
Butte Creek	474	0	47	891	1,412	100	1,412
Deer Creek	485	0	49	911	1,444	100	1,444
Mill Creek	723	0	72	1,358	2,154	100	2,154
Sacramento River mainstem	862	0	172	1,767	2,801	100	2,801
Total	2,544	0	341	4,927	7,811		7,811
Total 1994 Natural Production of Adult Chinook Salmon							**393,066**

NE = No Estimate

1995 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	80,330	6,498	39,073	300,112	426,013	60	255,608
Antelope Creek						80	
Battle Creek	56,515	26,677	8,319	218,164	309,675	10	30,968
Bear River						100	
Big Chico Creek						100	
Butte Creek	445	0	45	1,195	1,684	80	1,347
Clear Creek	9,298	0	930	24,395	34,623	80	27,699
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	59,912	17,563	15,495	221,649	314,619	60	188,771
Merced River	2,320	602	146	7,269	10,337	90	9,303
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	2,194	3,323	552	14,438	20,507	60	12,304
Paynes Creek						80	
Sacramento River mainstem	63,934	0	6,393	167,681	238,008	60	142,805
Stanislaus River	619	0	31	1,593	2,243	100	2,243
Tuolumne River	827	0	41	2,091	2,959	100	2,959
Yuba River	14,237	0	1,424	37,340	53,001	100	53,001
Total	290,631	54,663	72,448	995,927	1,413,670		727,008
Late-Fall Run Chinook Salmon							
Battle Creek	0	323	65	948	1,336	10	134
Sacramento River mainstem	166	0	33	487	686	91.8	630
Total	166	323	98	1,435	2,022		764
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,166	43	0	2,870	4,079	100	4,079
Calaveras River							
Total	1,166	43	0	2,870	4,079	100	4,079
Spring-Run Chinook Salmon							
Butte Creek	7,500	0	750	19,663	27,913	100	27,913
Deer Creek	1,295	0	130	3,396	4,820	100	4,820
Mill Creek	320	0	32	839	1,191	100	1,191
Sacramento River mainstem	426	0	85	1,218	1,729	100	1,729
Total	9,541	0	997	25,116	35,654		35,654
Total 1995 Natural Production of Adult Chinook Salmon							**767,505**

NE = No Estimate

1996 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	74,745	7,651	37,078	129,708	249,182	60	149,509
Antelope Creek						80	
Battle Creek	52,409	21,178	7,359	87,888	168,834	10	16,883
Bear River						100	
Big Chico Creek						100	
Butte Creek	500	0	50	614	1,164	80	931
Clear Creek	5,922	0	592	7,080	13,594	80	10,875
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	57,170	14,488	14,332	93,363	179,353	60	107,612
Merced River	3,291	1,141	222	5,050	9,704	90	8,734
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	4,038	3,883	792	9,440	18,153	60	10,892
Paynes Creek						80	
Sacramento River mainstem	84,086	0	8,409	100,396	192,891	60	115,735
Stanislaus River	168	0	8	189	365	100	365
Tuolumne River	4,362	0	218	4,956	9,536	100	9,536
Yuba River	27,900	0	2,790	33,324	64,014	100	64,014
Total	314,591	48,341	71,850	472,009	906,790		495,086
Late-Fall Run Chinook Salmon							
Battle Creek	0	1,337	267	1,754	3,358	10	336
Sacramento River mainstem	48	0	10	63	121	91.8	111
Total	48	1337	277	1,817	3,479		447
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,012	0	0	1,100	2,112	100	2,112
Calaveras River							
Total	1,012	0	0	1,100	2,112	100	2,112
Spring-Run Chinook Salmon							
Butte Creek	1,413	0	141	1,681	3,235	100	3,235
Deer Creek	614	0	61	731	1,406	100	1,406
Mill Creek	253	0	25	301	579	100	579
Sacramento River mainstem	378	0	76	491	944	100	944
Total	2,658	0	304	3,204	6,165		6,165
Total 1996 Natural Production of Adult Chinook Salmon							**503,810**

NE = No Estimate

1997 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	52,195	5,650	26,030	118,956	202,831	60	121,699
Antelope Creek						80	
Battle Creek	50,744	50,670	10,141	158,223	269,778	10	26,978
Bear River						100	
Big Chico Creek						100	
Butte Creek	800	0	80	1,223	2,103	80	1,682
Clear Creek	8,569	0	857	13,383	22,809	80	18,247
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	1,203	0	120	1,902	3,226	80	2,580
Feather River	50,547	18,781	13,866	118,005	201,198	60	120,719
Merced River	2,714	946	183	5,435	9,278	90	8,350
Mill Creek	478	0	48	747	1,273	80	1,018
"miscellaneous creeks"						80	
Mokelumne River	3,681	6,494	1,018	15,897	27,089	60	16,254
Paynes Creek						80	
Sacramento River mainstem	119,296	0	11,930	186,144	317,370	60	190,422
Stanislaus River	5,588	0	279	8,356	14,224	100	14,224
Tuolumne River	7,146	0	357	10,666	18,169	100	18,169
Yuba River	25,948	0	2,595	40,490	69,033	100	69,033
Total	328,909	82,541	67,504	679,427	1,158,381		609,375
Late-Fall Run Chinook Salmon							
Battle Creek	0	4,578	916	7,804	13,298	10	1,330
Sacramento River mainstem						91.8	
Total	0	4578	916	7,804	13,298		1,330
Winter-Run Chinook Salmon							
Sacramento River mainstem	836	0	0	1,174	2,010	100	2,010
Calaveras River							
Total	836	0	0	1,174	2,010	100	2,010
Spring-Run Chinook Salmon							
Butte Creek	635	0	64	1,003	1,702	100	1,702
Deer Creek	466	0	47	736	1,249	100	1,249
Mill Creek	202	0	20	319	541	100	541
Sacramento River mainstem	128	0	26	221	374	100	374
Total	1,431	0	156	2,279	3,866		3,866
Total 1997 Natural Production of Adult Chinook Salmon							**616,581**

NE = No Estimate

1998 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	54,792	11,788	29,961	83,619	180,160	60	108,096
Antelope Creek						80	
Battle Creek	53,957	44,351	9,831	93,645	201,783	10	20,178
Bear River						100	
Big Chico Creek						100	
Butte Creek	500	0	50	480	1,030	80	824
Clear Creek	4,259	0	426	4,053	8,738	80	6,990
Cosumnes River	300	0	30	293	623	100	623
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	270	0	27	267	564	80	451
Feather River	0	25,635	5,127	26,638	57,400	60	34,440
Merced River	3,292	799	205	3,733	8,029	90	7,226
Mill Creek	546	0	55	533	1,134	80	907
"miscellaneous creeks"						80	
Mokelumne River	4,122	3,091	721	6,879	14,814	60	8,888
Paynes Creek						80	
Sacramento River mainstem	6,318	0	632	6,026	12,976	60	7,786
Stanislaus River	3,087	0	154	2,800	6,041	100	6,041
Tuolumne River	8,910	0	446	8,106	17,461	100	17,461
Yuba River	31,090	0	3,109	29,624	63,823	100	63,823
Total	171,443	85,664	50,773	266,695	574,575		283,734
Late-Fall Run Chinook Salmon							
Battle Creek	0	3,079	616	3,200	6,895	10	690
Sacramento River mainstem	39,340	0	7,868	40,882	88,090	91.8	80,866
Total	39,340	3,079	8,484	44,082	94,985		81,556
Winter-Run Chinook Salmon							
Sacramento River mainstem	2,893	99	0	2,587	5,579	100	5,579
Calaveras River							
Total	2,893	99	0	2,587	5,579	100	5,579
Spring-Run Chinook Salmon							
Butte Creek	20,259	0	2,026	19,294	41,579	100	41,579
Deer Creek	1,879	0	188	1,789	3,856	100	3,856
Mill Creek	424	0	42	403	869	100	869
Sacramento River mainstem	1,115	0	223	1,159	2,497	100	2,497
Total	23,677	0	2,479	22,646	48,802		48,802
Total 1998 Natural Production of Adult Chinook Salmon							**419,671**

NE = No Estimate

1999 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	55,339	9,760	29,295	61,956	156,350	60	93,810
Antelope Creek						80	
Battle Creek	92,929	26,970	11,990	86,561	218,450	10	21,845
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	8,003	0	800	5,771	14,574	80	11,659
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	0	16,658	3,332	13,127	33,116	60	19,870
Merced River	3,129	1,637	238	3,298	8,302	90	7,472
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	2,183	3,150	533	3,837	9,703	60	5,822
Paynes Creek						80	
Sacramento River mainstem	161,192	0	16,119	116,366	293,677	60	176,206
Stanislaus River	4,349	0	217	3,012	7,579	100	7,579
Tuolumne River	8,232	0	412	5,676	14,319	100	14,319
Yuba River	24,230	0	2,423	17,502	44,155	100	44,155
Total	359,586	58,175	65,359	317,104	800,225		402,737
Late-Fall Run Chinook Salmon							
Battle Creek	0	7,075	1,415	5,568	14,058	10	1,406
Sacramento River mainstem	8,683	0	1,737	6,833	17,252	91.8	15,838
Total	8,683	7,075	3,152	12,401	31,310		17,243
Winter-Run Chinook Salmon							
Sacramento River mainstem	3,264	24	0	2,151	5,439	100	5,439
Calaveras River							
Total	3,264	24	0	2,151	5,439	100	5,439
Spring-Run Chinook Salmon							
Butte Creek	3,679	0	368	2,648	6,695	100	6,695
Deer Creek	1,591	0	159	1,145	2,895	100	2,895
Mill Creek	560	0	56	403	1,019	100	1,019
Sacramento River mainstem	262	0	52	206	520	100	520
Total	6,092	0	635	4,402	11,130		11,130
Total 1999 Natural Production of Adult Chinook Salmon							**436,549**

NE = No Estimate

2000 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	99,059	11,160	49,599	155,922	315,740	60	189,444
Antelope Creek						80	
Battle Creek	53,447	21,659	7,511	80,620	163,236	10	16,324
Bear River						100	
Big Chico Creek						100	
Butte Creek						80	
Clear Creek	6,687	0	669	7,204	14,560	80	11,648
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	114,717	21,803	27,304	159,810	323,634	60	194,181
Merced River	11,130	1,946	654	13,379	27,109	90	24,398
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	1,973	5,450	742	7,948	16,113	60	9,668
Paynes Creek						80	
Sacramento River mainstem	96,688	0	9,669	103,777	210,133	60	126,080
Stanislaus River	8,498	0	425	8,691	17,614	100	17,614
Tuolumne River	17,873	0	894	18,297	37,063	100	37,063
Yuba River	14,995	0	1,500	16,067	32,561	100	32,561
Total	425,067	62,018	98,965	571,715	1,157,765		658,981
Late-Fall Run Chinook Salmon							
Battle Creek	0	4,194	839	4,908	9,940	10	994
Sacramento River mainstem	8,751	0	1,750	10,239	20,740	91.8	19,040
Total	8,751	4,194	2,589	15,147	30,681		20,034
Winter-Run Chinook Salmon							
Sacramento River mainstem	1,263	89	0	1,307	2,659	100	2,659
Calaveras River							
Total	1,263	89	0	1,307	2,659	100	2,659
Spring-Run Chinook Salmon							
Butte Creek	4,118	0	412	4,413	8,943	100	8,943
Deer Creek	637	0	64	683	1,383	100	1,383
Mill Creek	544	0	54	583	1,181	100	1,181
Sacramento River mainstem	71	0	14	83	168	100	168
Total	5,370	0	544	5,762	11,676		11,676
Total 2000 Natural Production of Adult Chinook Salmon							**693,349**

NE = No Estimate

2001 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	135,384	11,750	66,210	61,035	274,379	60	164,627
Antelope Creek						80	
Battle Creek	100,604	25,082	12,569	39,541	177,795	10	17,780
Bear River						100	
Big Chico Creek						100	
Butte Creek	4,433	0	443	1,397	6,273	80	5,018
Clear Creek	10,865	0	1,087	3,426	15,377	80	12,302
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	178,645	29,005	41,530	71,269	320,449	60	192,269
Merced River	9,181	1,663	542	3,251	14,638	90	13,174
Mill Creek						80	
"miscellaneous creeks"						80	
Mokelumne River	2,307	5,728	804	2,531	11,370	60	6,822
Paynes Creek						80	
Sacramento River mainstem	75,152	0	7,515	23,654	106,322	60	63,793
Stanislaus River	7,033	0	352	2,117	9,501	100	9,501
Tuolumne River	8,782	0	439	2,640	11,862	100	11,862
Yuba River	23,392	0	2,339	7,354	33,085	100	33,085
Total	555,778	73,228	133,830	218,215	981,050		530,233
Late-Fall Run Chinook Salmon							
Battle Creek	0	3,327	665	1,143	5,135	10	514
Sacramento River mainstem	19,276	0	3,855	6,621	29,753	91.8	27,313
Total	19,276	3,327	4,521	7,764	34,888		27,826
Winter-Run Chinook Salmon							
Sacramento River mainstem	8,120	104	0	2,348	10,572	100	10,572
Calaveras River							
Total	8,120	104	0	2,348	10,572	100	10,572
Spring-Run Chinook Salmon							
Butte Creek	9,605	0	961	3,027	13,592	100	13,592
Deer Creek	1,622	0	162	511	2,295	100	2,295
Mill Creek	1,100	0	110	347	1,557	100	1,557
Sacramento River mainstem	736	0	147	253	1,136	100	1,136
Total	13,063	0	1,380	4,138	18,581		18,581
Total 2001 Natural Production of Adult Chinook Salmon							**587,213**

NE = No Estimate

2002 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	124,252	9,817	60,331	79,815	274,215	60	164,529
Antelope Creek						80	
Battle Creek	397,149	66,147	46,330	209,272	718,898	10	71,890
Bear River						100	
Big Chico Creek						100	
Butte Creek	3,665	0	367	1,637	5,668	80	4,534
Clear Creek	16,071	0	1,607	7,260	24,938	80	19,950
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	105,163	24,696	25,972	63,994	219,825	60	131,895
Merced River	8,866	1,840	535	4,616	15,857	90	14,272
Mill Creek	2,611	0	261	1,175	4,047	80	3,238
"miscellaneous creeks"						80	
Mokelumne River	2,840	7,913	1,075	4,868	16,696	60	10,018
Paynes Creek						80	
Sacramento River mainstem	65,690	0	6,569	29,668	101,927	60	61,156
Stanislaus River	7,787	0	389	3,357	11,533	100	11,533
Tuolumne River	7,173	0	359	3,105	10,637	100	10,637
Yuba River	24,051	0	2,405	10,869	37,325	100	37,325
Total	765,318	110,413	146,200	419,635	1,441,566		540,977
Late-Fall Run Chinook Salmon							
Battle Creek	0	2,669	534	1,316	4,518	10	452
Sacramento River mainstem	36,004	0	7,201	17,751	60,955	91.8	55,957
Total	36,004	2,669	7,735	19,066	65,474		56,409
Winter-Run Chinook Salmon							
Sacramento River mainstem	7,360	104	0	3,043	10,508	100	10,508
Calaveras River							
Total	7,360	104	0	3,043	10,508	100	10,508
Spring-Run Chinook Salmon							
Butte Creek	8,785	0	879	3,974	13,637	100	13,637
Deer Creek	2,185	0	219	989	3,392	100	3,392
Mill Creek	1,594	0	159	721	2,474	100	2,474
Sacramento River mainstem	273	0	55	135	463	100	463
Total	12,837	0	1,311	5,818	19,966		19,966
Total 2002 Natural Production of Adult Chinook Salmon							**627,860**

NE = No Estimate

2003 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	163,742	14,887	80,383	105,140	364,152	60	218,491
Antelope Creek						80	
Battle Creek	64,764	88,281	15,305	68,338	236,688	10	23,669
Bear River						100	
Big Chico Creek						100	
Butte Creek	3,492	0	349	1,547	5,388	80	4,311
Clear Creek	9,475	0	948	4,225	14,647	80	11,718
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek						80	
Feather River	89,946	23,638	22,717	55,337	191,638	60	114,983
Merced River	2,530	549	154	1,309	4,542	90	4,088
Mill Creek	2,426	0	243	1,071	3,740	80	2,992
"miscellaneous creeks"						80	
Mokelumne River	2,122	8,117	1,024	4,582	15,845	60	9,507
Paynes Creek						80	
Sacramento River mainstem	89,229	0	8,923	39,837	137,989	60	82,793
Stanislaus River	5,902	0	295	2,529	8,726	100	8,726
Tuolumne River	2,163	0	108	922	3,193	100	3,193
Yuba River	28,316	0	2,832	12,644	43,792	100	43,792
Total	464,107	135,472	133,279	297,481	1,030,339		528,262
Late-Fall Run Chinook Salmon							
Battle Creek	0	2,797	559	1,365	4,721	10	472
Sacramento River mainstem	5,494	0	1,099	2,680	9,272	91.8	8,512
Total	5,494	2,797	1,658	4,044	13,993		8,984
Winter-Run Chinook Salmon							
Sacramento River mainstem	8,133	85	0	3,334	11,552	100	11,552
Calaveras River							
Total	8,133	85	0	3,334	11,552	100	11,552
Spring-Run Chinook Salmon							
Butte Creek	4,398	0	440	1,962	6,799	100	6,799
Deer Creek	2,759	0	276	1,230	4,265	100	4,265
Mill Creek	1,426	0	143	636	2,204	100	2,204
Sacramento River mainstem	0	0	0	0	0	0	0
Total	8,583	0	858	3,828	13,269		13,269
Total 2003 Natural Production of Adult Chinook Salmon							**562,067**

NE = No Estimate

2004 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	99,230	26,400	56,534	190,548	372,711	60	223,627
Antelope Creek						80	
Battle Creek	23,861	68,232	9,209	105,977	207,279	10	20,728
Bear River						100	
Big Chico Creek						100	
Butte Creek	2,516	0	252	2,908	5,675	80	4,540
Clear Creek	6,365	0	637	7,319	14,321	80	11,456
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	300	0	30	351	681	80	545
Feather River	54,171	25,509	15,936	100,011	195,627	60	117,376
Merced River	1,050	3,270	216	4,762	9,298	90	8,369
Mill Creek	1,192	0	119	1,354	2,665	80	2,132
"miscellaneous creeks"						80	
Mokelumne River	1,588	10,356	1,194	13,736	26,874	60	16,125
Paynes Creek						80	
Sacramento River mainstem	43,604	0	4,360	50,181	98,145	60	58,887
Stanislaus River	4,015	0	201	4,412	8,627	100	8,627
Tuolumne River	1,984	0	99	2,156	4,239	100	4,239
Yuba River	15,269	0	1,527	17,546	34,342	100	34,342
Total	255,145	133,767	90,314	501,259	980,485		510,992
Late-Fall Run Chinook Salmon							
Battle Creek	0	5,040	1,008	6,317	12,365	10	1,236
Sacramento River mainstem	8,824	0	1,765	11,061	21,650	91.8	19,874
Total	8,824	5,040	2,773	17,377	34,014		21,111
Winter-Run Chinook Salmon							
Sacramento River mainstem	7,784	85	0	8,231	16,101	100	16,101
Calaveras River							
Total	7,784	85	0	8,231	16,101	100	16,101
Spring-Run Chinook Salmon							
Butte Creek	7,390	0	739	8,512	16,641	100	16,641
Deer Creek	804	0	80	927	1,811	100	1,811
Mill Creek	998	0	100	1,149	2,247	100	2,247
Sacramento River mainstem	394	0	79	495	968	100	968
Total	9,586	0	998	11,083	21,667		21,667
Total 2004 Natural Production of Adult Chinook Salmon							**569,871**

NE = No Estimate

2005 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	56,843	22,349	35,636	79,746	194,574	60	116,745
Antelope Creek						80	
Battle Creek	20,520	142,283	16,280	124,365	303,448	10	30,345
Bear River						100	
Big Chico Creek						100	
Butte Creek	4,255	0	426	3,235	7,916	80	6,333
Clear Creek	14,824	0	1,482	11,306	27,612	80	22,090
Cosumnes River						100	
Cottonwood Creek						80	
Cow Creek						80	
Deer Creek	946	0	95	711	1,752	80	1,401
Feather River	48,586	23,972	14,512	60,476	147,546	60	88,527
Merced River	2,111	421	127	1,849	4,507	90	4,057
Mill Creek	2,426	0	243	1,849	4,517	80	3,614
"miscellaneous creeks"						80	
Mokelumne River	10,406	5,722	1,613	12,337	30,078	60	18,047
Paynes Creek						80	
Sacramento River mainstem	57,012	0	5,701	43,553	106,266	60	63,760
Stanislaus River	3,315	0	166	2,418	5,898	100	5,898
Tuolumne River	719	0	36	533	1,288	100	1,288
Yuba River	17,238	0	1,724	13,155	32,116	100	32,116
Total	239,201	194,747	78,040	355,532	867,520		394,220
Late-Fall Run Chinook Salmon							
Battle Creek	0	6,435	1,287	5,369	13,091	10	1,309
Sacramento River mainstem	10,600	0	2,120	8,842	21,562	91.8	19,794
Total	10,600	6,435	3,407	14,210	34,652		21,103
Winter-Run Chinook Salmon							
Sacramento River mainstem	15,730	145	0	11,039	26,915	100	26,915
Calaveras River							
Total	15,730	145	0	11,039	26,915	100	26,915
Spring-Run Chinook Salmon							
Butte Creek	10,625	0	1,063	8,113	19,801	100	19,801
Deer Creek	2,239	0	224	1,710	4,173	100	4,173
Mill Creek	1,150	0	115	878	2,143	100	2,143
Sacramento River mainstem	30	0	6	25	61	100	61
Total	14,044	0	1,407	10,726	26,178		26,178
Total 2005 Natural Production of Adult Chinook Salmon							**468,416**

NE = No Estimate

2006 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	22,900	8,728	14,233	14,810	60,670	60	36,402
Antelope Creek						80	
Battle Creek	19,559	58,022	7,758	27,554	112,893	10	11,289
Bear River						100	
Big Chico Creek						100	
Butte Creek	1,920	0	192	685	2,797	80	2,237
Clear Creek	8,422	0	842	2,993	12,257	80	9,806
Cosumnes River	530	0	53	188	771	100	771
Cottonwood Creek						80	
Cow Creek	4,130	0	413	1,469	6,012	80	4,809
Deer Creek	1,905	0	191	674	2,769	80	2,215
Feather River	75,430	16,095	18,305	35,462	145,292	60	87,175
Merced River	1,470	151	81	552	2,254	90	2,029
Mill Creek	1,403	0	140	497	2,040	80	1,632
"miscellaneous creeks"						80	
Mokelumne River	1,732	4,139	587	2,087	8,545	60	5,127
Paynes Creek						80	
Sacramento River mainstem	55,468	0	5,547	19,702	80,717	60	48,430
Stanislaus River	1,923	0	96	652	2,671	100	2,671
Tuolumne River	625	0	31	210	866	100	866
Yuba River	8,231	0	823	2,927	11,981	100	11,981
Total	205,648	87,135	49,292	110,460	452,536		227,441
Late-Fall Run Chinook Salmon							
Battle Creek	0	5,109	1,022	1,978	8,109	10	811
Sacramento River mainstem	10,171	0	2,034	3,937	16,142	91.8	14,819
Total	10,171	5,109	3,056	5,915	24,251		15,629
Winter-Run Chinook Salmon							
Sacramento River mainstem	17,205	98	0	5,591	22,894	100	22,894
Calaveras River							
Total	17,205	98	0	5,591	22,894	100	22,894
Spring-Run Chinook Salmon							
Butte Creek	4,579	0	458	1,626	6,663	100	6,663
Deer Creek	2,432	0	243	864	3,539	100	3,539
Mill Creek	1,002	0	100	356	1,458	100	1,458
Sacramento River mainstem	0	0	0	0	0	0	0
Total	8,013	0	801	2,845	11,659		11,659
Total 2006 Natural Production of Adult Chinook Salmon							**277,624**

NE = No Estimate

2007 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	9,985	4,597	6,562	15,926	37,070	60	22,242
Antelope Creek						80	
Battle Creek	9,904	11,778	2,168	17,964	41,815	10	4,181
Bear River						100	
Big Chico Creek						100	
Butte Creek	1,225	0	123	1,019	2,367	80	1,893
Clear Creek	4,129	0	413	3,417	7,959	80	6,367
Cosumnes River	53	0	5	44	102	100	102
Cottonwood Creek	1,250	0	125	1,037	2,412	80	1,929
Cow Creek	2,044	0	204	1,695	3,944	80	3,155
Deer Creek	508	0	51	422	980	80	784
Feather River	21,862	8,015	5,975	27,004	62,856	60	37,714
Merced River	495	79	29	457	1,059	90	954
Mill Creek	796	0	80	659	1,534	80	1,228
"miscellaneous creeks"	140	0	14	114	268	80	215
Mokelumne River	470	1,051	152	1,256	2,929	60	1,758
Paynes Creek						80	
Sacramento River mainstem	17,061	0	1,706	14,134	32,901	60	19,741
Stanislaus River	443	0	22	351	817	100	817
Tuolumne River	224	0	11	176	411	100	411
Yuba River	2,604	0	260	2,161	5,025	100	5,025
Total	73,193	25,520	17,901	87,837	204,450		108,516
Late-Fall Run Chinook Salmon							
Battle Creek	0	3,319	664	3,000	6,983	10	698
Sacramento River mainstem	15,341	89	3,086	13,949	32,465	91.8	29,803
Total	15,341	3,408	3,750	16,949	39,448		30,501
Winter-Run Chinook Salmon							
Sacramento River mainstem	2,487	55	0	1,909	4,451	100	4,451
Calaveras River							
Total	2,487	55	0	1,909	4,451	100	4,451
Spring-Run Chinook Salmon							
Butte Creek	4,943	0	494	4,096	9,533	100	9,533
Deer Creek	644	0	64	534	1,242	100	1,242
Mill Creek	920	0	92	762	1,774	100	1,774
Sacramento River mainstem	248	0	50	224	522	100	522
Total	6,755	0	700	5,615	13,071		13,071
Total 2007 Natural Production of Adult Chinook Salmon							**156,539**

NE = No Estimate

2008 Adult Chinook Salmon Production Estimates							
Watershed	**In-river spawner abundance**	**Fish entering a hatchery**	**Estimated in-river harvest**	**Ocean harvest**	**Total production**	**Percent natural production**	**Natural production**
Fall-Run Chinook Salmon							
American River	2,742	3,184	0	0	5,926	60	3,556
Antelope Creek						80	
Battle Creek	4,290	10,635	0	0	14,925	10	1,493
Bear River						100	
Big Chico Creek						100	
Butte Creek	275	0	0	0	275	80	220
Clear Creek	7,677	0	0	0	7,677	80	6,142
Cosumnes River						100	
Cottonwood Creek	200	0	0	0	200	80	160
Cow Creek	200	0	0	0	200	80	160
Deer Creek	194	0	0	0	194	80	155
Feather River	8,208	6,420	0	0	14,628	60	8,777
Merced River	566	62	0	0	628	90	565
Mill Creek	166	0	0	0	166	80	133
"miscellaneous creeks"	20	0	0	0	20	80	16
Mokelumne River	140	239	0	0	379	60	227
Paynes Creek						80	
Sacramento River mainstem	25,197	0	0	0	25,197	60	15,118
Stanislaus River	1,305	0	0	0	1,305	100	1,305
Tuolumne River	455	0	0	0	455	100	455
Yuba River	3,613	0	0	0	3,613	100	3,613
Total	55,248	20,540	0	0	75,788		42,094
Late-Fall Run Chinook Salmon							
Battle Creek	0	6,142	0	0	6,142	10	614
Sacramento River mainstem	4,063	17	596	0	4,676	91.8	4,292
Total	4,063	6,159	596	0	10,818		4,906
Winter-Run Chinook Salmon							
Sacramento River mainstem	2,745	105	0	0	2,850	100	2,850
Calaveras River							
Total	2,745	105	0	0	2,850	100	2,850
Spring-Run Chinook Salmon							
Butte Creek	3,935	0	0	0	3,935	100	3,935
Deer Creek	140	0	0	0	140	100	140
Mill Creek	362	0	0	0	362	100	362
Sacramento River mainstem						100	
Total	4,437	0	0	0	4,437		4,437
Total 2008 Natural Production of Adult Chinook Salmon							**54,288**

NE = No Estimate

APPENDIX B: RAW DATA USED TO CALCULATE THE YOUNG-OF-THE-YEAR INDEX FOR JUVENILE AMERICAN SHAD

The indices below are based on the fall midwater trawl surveys conducted by the California Department of Fish and Game (CDFG). Data on the all ages abundance index is derived from CDFG's "AMESHA FMWT Indices 1967-2008.xls" spreadsheet dated September 9, 2009. Data used to determine the proportion of American shad belonging to the young-of-the-year age class are derived from CDFG's "AMS Length Frequency 1971-2008.xls" spreadsheet dated November 3, 2009. NS = no sampling.

Grey-shaded cells denote periods when length frequency data were not collected. To develop YOY abundance indices for such months (i.e., all months in 1967, 1968, 1969, 1970, and 1984; September of 1971 and 1973; and September and December of 1976), the 10-year average abundance for YOY fish in a particular month in 1972, 1975, 1977, 1978, 1980-1983, 1985, and 1986 was multiplied by the all age abundance index in a month when length frequency data were not available. For example, the YOY abundance index in September 1967 was calculated by multiplying the all age abundance index for September 1967 by the average percent YOY value for the month of September during the 10-year period of 1972, 1975, 1977, 1978, 1980-1983, 1985, and 1986; i.e., 1505 * 0.99 = 1490.

YOY length criteria

Month	Fork Length
Sept.	< 150.9 mm
Oct.	< 156.9 mm
Nov.	< 161.9 mm
Dec.	< 164.9 mm

The MWT index for 1976 is unusually low because sampling did not occur in September and December.

year		monthly index				annual index
		September	October	November	December	
1967	all age abundance index	1,519	1,091	607	205	3,422
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	1,499	1,080	603	203	3,386
1968	all age abundance index	274	277	137	70	758
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	270	274	136	69	750
1969	all age abundance index	1,320	1,177	789	402	3,688
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	1,303	1,166	784	398	3,651
1970	all age abundance index	366	254	170	66	856
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	361	252	169	65	847
1971	all age abundance index	351	473	380	255	1,459
	number of fish older than age 0 measured		3	1	0	
	number of YOY measured		136	89	45	
	total number of fish measured		139	90	45	
	percent YOY (estimated in Sept.)	98.7	97.8	98.9	100.0	
	YOY abundance index	346	463	376	255	1,440
1972	all age abundance index	140	56	109	30	335
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	7	24	27	13	
	total number of fish measured	7	24	27	13	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	140	56	109	30	335
1973	all age abundance index	599	193	211	82	1,085
	number of fish older than age 0 measured		1	0	0	
	number of YOY measured		77	84	28	
	total number of fish measured		78	84	28	
	percent YOY (estimated in Sept.)	98.7	98.7	100.0	100.0	
	YOY abundance index	591	191	211	82	1,075
1974	all age abundance index	NS	NS	NS	NS	NS
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	percent YOY					
	YOY abundance index	NS	NS	NS	NS	NS
1975	all age abundance index	1,240	587	486	178	2,491
	number of fish older than age 0 measured	5	0	1	0	
	number of YOY measured	423	251	243	106	
	total number of fish measured	428	251	244	106	
	percent YOY	98.8	100.0	99.6	100.0	
	YOY abundance index	1,226	587	484	178	2,475

year		monthly index				annual index
		September	October	November	December	
1976	all age abundance index	NS	69	102	NS	171
	number of fish older than age 0 measured		0	0		
	number of YOY measured		40	64		
	total number of fish measured		40	64		
	percent YOY (estimated in Sept. and Decem.)		100.0	100.0		
	YOY abundance index	NS	69	102	NS	171
1977	all age abundance index	126	147	233	130	636
	number of fish older than age 0 measured	2	1	1	0	
	number of YOY measured	84	97	127	74	
	total number of fish measured	86	98	128	74	
	percent YOY	97.7	99.0	99.2	100.0	
	YOY abundance index	123	146	231	130	630
1978	all age abundance index	762	1,060	321	221	2,364
	number of fish older than age 0 measured	1	1	2	1	
	number of YOY measured	304	247	181	124	
	total number of fish measured	305	248	183	125	
	percent YOY	99.7	99.6	98.9	99.2	
	YOY abundance index	760	1,056	317	219	2,352
1979	all age abundance index	NS	NS	NS	NS	NS
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	percent YOY					
	YOY abundance index	NS	NS	NS	NS	NS
1980	all age abundance index	1,295	1,697	523	401	3,916
	number of fish older than age 0 measured	13	13	2	5	
	number of YOY measured	213	218	196	134	
	total number of fish measured	226	231	198	139	
	percent YOY	94.2	94.4	99.0	96.4	
	YOY abundance index	1,221	1,601	518	387	3,726
1981	all age abundance index	286	522	349	277	1,434
	number of fish older than age 0 measured	2	4	4	1	
	number of YOY measured	183	265	192	62	
	total number of fish measured	185	269	196	63	
	percent YOY	98.9	98.5	98.0	98.4	
	YOY abundance index	283	514	342	273	1,412
1982	all age abundance index	2,245	1,609	1,325	210	5,389
	number of fish older than age 0 measured	3	2	0	1	
	number of YOY measured	583	587	502	113	
	total number of fish measured	586	589	502	114	
	percent YOY	99.5	99.7	100.0	99.1	
	YOY abundance index	2,234	1,604	1,325	208	5,370
1983	all age abundance index	962	852	958	159	2,931
	number of fish older than age 0 measured	0	1	2	1	
	number of YOY measured	433	316	366	73	
	total number of fish measured	433	317	368	74	
	percent YOY	100.0	99.7	99.5	98.6	
	YOY abundance index	962	849	953	157	2,921
1984	all age abundance index	292	172	267	86	817
	number of fish older than age 0 measured					
	number of YOY measured					
	total number of fish measured					
	estimated percent YOY	98.7	99.0	99.4	99.1	
	YOY abundance index	288	170	265	85	809

year		monthly index				annual index
		September	October	November	December	
1985	all age abundance index	316	332	564	386	1,598
	number of fish older than age 0 measured	0	1	2	1	
	number of YOY measured	204	236	350	197	
	total number of fish measured	204	237	352	198	
	percent YOY	100.0	99.6	99.4	99.5	
	YOY abundance index	316	331	561	384	1,591
1986	all age abundance index	694	567	313	286	1,860
	number of fish older than age 0 measured	3	0	0	0	
	number of YOY measured	146	206	148	131	
	total number of fish measured	149	206	148	131	
	percent YOY	98.0	100.0	100.0	100.0	
	YOY abundance index	680	567	313	286	1,846
1987	all age abundance index	261	292	222	124	899
	number of fish older than age 0 measured	19	10	0	0	
	number of YOY measured	160	157	100	66	
	total number of fish measured	179	167	100	66	
	percent YOY	89.4	94.0	100.0	100.0	
	YOY abundance index	233	275	222	124	854
1988	all age abundance index	805	310	300	135	1,550
	number of fish older than age 0 measured	1	1	4	0	
	number of YOY measured	302	204	150	69	
	total number of fish measured	303	205	154	69	
	percent YOY	99.7	99.5	97.4	100.0	
	YOY abundance index	802	308	292	135	1,538
1989	all age abundance index	569	339	592	378	1,878
	number of fish older than age 0 measured	1	0	0	1	
	number of YOY measured	263	223	299	192	
	total number of fish measured	264	223	299	193	
	percent YOY	99.6	100.0	100.0	99.5	
	YOY abundance index	567	339	592	376	1,874
1990	all age abundance index	1,493	947	1,369	507	4,316
	number of fish older than age 0 measured	0	2	5	4	
	number of YOY measured	435	355	540	232	
	total number of fish measured	435	357	545	236	
	percent YOY	100.0	99.4	99.1	98.3	
	YOY abundance index	1,493	942	1,356	498	4,290
1991	all age abundance index	1,076	780	872	260	2,988
	number of fish older than age 0 measured	2	0	2	0	
	number of YOY measured	461	435	409	153	
	total number of fish measured	463	435	411	153	
	percent YOY	99.6	100.0	99.5	100.0	
	YOY abundance index	1,071	780	868	260	2,979
1992	all age abundance index	755	530	463	262	2,010
	number of fish older than age 0 measured	0	0	1	1	
	number of YOY measured	404	319	293	121	
	total number of fish measured	404	319	294	122	
	percent YOY	100.0	100.0	99.7	99.2	
	YOY abundance index	755	530	461	260	2,006
1993	all age abundance index	1,972	1,567	908	710	5,157
	number of fish older than age 0 measured	0	0	1	1	
	number of YOY measured	557	432	382	362	
	total number of fish measured	557	432	383	363	
	percent YOY	100.0	100.0	99.7	99.7	
	YOY abundance index	1,972	1,567	906	708	5,153

year		monthly index				annual index
		September	October	November	December	
1994	all age abundance index	439	387	391	117	1,334
	number of fish older than age 0 measured	5	4	2	1	
	number of YOY measured	421	270	327	71	
	total number of fish measured	426	274	329	72	
	percent YOY	98.8	98.5	99.4	98.6	
	YOY abundance index	434	381	389	115	1,319
1995	all age abundance index	3,246	2,220	791	555	6,812
	number of fish older than age 0 measured	2	1	0	0	
	number of YOY measured	979	774	484	345	
	total number of fish measured	981	775	484	345	
	percent YOY	99.8	99.9	100.0	100.0	
	YOY abundance index	3,239	2,217	791	555	6,803
1996	all age abundance index	1,756	1,072	935	523	4,286
	number of fish older than age 0 measured	2	5	3	2	
	number of YOY measured	632	509	507	245	
	total number of fish measured	634	514	510	247	
	percent YOY	99.7	99.0	99.4	99.2	
	YOY abundance index	1,750	1,062	930	519	4,260
1997	all age abundance index	265	565	639	1,125	2,594
	number of fish older than age 0 measured	2	1	0	0	
	number of YOY measured	325	338	347	611	
	total number of fish measured	327	339	347	611	
	percent YOY	99.4	99.7	100.0	100.0	
	YOY abundance index	263	563	639	1,125	2,591
1998	all age abundance index	1,318	2,093	515	214	4,140
	number of fish older than age 0 measured	1	0	2	0	
	number of YOY measured	622	638	275	99	
	total number of fish measured	623	638	277	99	
	percent YOY	99.8	100.0	99.3	100.0	
	YOY abundance index	1,316	2,093	511	214	4,134
1999	all age abundance index	346	155	145	69	715
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	228	184	149	86	
	total number of fish measured	228	184	149	86	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	346	155	145	69	715
2000	all age abundance index	253	326	126	59	764
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	132	278	107	41	
	total number of fish measured	132	278	107	41	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	253	326	126	59	764
2001	all age abundance index	338	239	110	78	765
	number of fish older than age 0 measured	0	0	0	2	
	number of YOY measured	311	230	114	40	
	total number of fish measured	311	230	114	42	
	percent YOY	100.0	100.0	100.0	95.2	
	YOY abundance index	338	239	110	74	761
2002	all age abundance index	372	831	334	382	1,919
	number of fish older than age 0 measured	1	2	0	1	
	number of YOY measured	286	478	242	236	
	total number of fish measured	287	480	242	237	
	percent YOY	99.7	99.6	100.0	99.6	
	YOY abundance index	371	828	334	380	1,913

year		monthly index				annual index
		September	October	November	December	
2003	all age abundance index	3,345	2,947	1,279	1,789	9,360
	number of fish older than age 0 measured	4	1	0	0	
	number of YOY measured	911	760	656	760	
	total number of fish measured	915	761	656	760	
	percent YOY	99.6	99.9	100.0	100.0	
	YOY abundance index	3,330	2,943	1,279	1,789	9,342
2004	all age abundance index	680	83	78	106	947
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	391	128	91	67	
	total number of fish measured	391	128	91	67	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	680	83	78	106	947
2005	all age abundance index	826	546	177	189	1,738
	number of fish older than age 0 measured	1	0	0	0	
	number of YOY measured	288	247	129	114	
	total number of fish measured	289	247	129	114	
	percent YOY	99.7	100.0	100.0	100.0	
	YOY abundance index	823	546	177	189	1,735
2006	all age abundance index	1,119	142	646	406	2,313
	number of fish older than age 0 measured	1	0	2	1	
	number of YOY measured	321	118	280	223	
	total number of fish measured	322	118	282	224	
	percent YOY	99.7	100.0	99.3	99.6	
	YOY abundance index	1,116	142	641	404	2,303
2007	all age abundance index	123	257	116	57	553
	number of fish older than age 0 measured	0	1	0	0	
	number of YOY measured	140	155	89	55	
	total number of fish measured	140	156	89	55	
	percent YOY	100.0	99.4	100.0	100.0	
	YOY abundance index	123	255	116	57	551
2008	all age abundance index	14	25	19	213	271
	number of fish older than age 0 measured	0	0	0	0	
	number of YOY measured	55	31	25	151	
	total number of fish measured	55	31	25	151	
	percent YOY	100.0	100.0	100.0	100.0	
	YOY abundance index	14	25	19	213	271
average percent YOY value for the 10-year period of 1972, 1975, 1977, 1978, 1980-1983, 1985, and 1986		98.68	99.03	99.36	99.13	